US008079195B2

(12) **United States Patent**
Cables

(10) **Patent No.: US 8,079,195 B2**
(45) **Date of Patent: Dec. 20, 2011**

(54) **MODULAR BLOCKS AND STRUCTURES MADE THEREFROM**

(76) Inventor: **Raymond Walter Cables**, Fort Mill, SC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 998 days.

(21) Appl. No.: **11/817,289**

(22) PCT Filed: **Nov. 11, 2005**

(86) PCT No.: **PCT/US2005/040709**

§ 371 (c)(1),
(2), (4) Date: **Aug. 28, 2007**

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PCT Pub. Date: **Sep. 8, 2006**

(65) **Prior Publication Data**

US 2008/0263986 A1 Oct. 30, 2008

Related U.S. Application Data

(60) Provisional application No. 60/657,226, filed on Feb. 28, 2005.

(51) **Int. Cl.**
E04B 1/02 (2006.01)

(52) **U.S. Cl.** **52/572**; 52/561; 52/604; 52/589.1

(58) **Field of Classification Search** 52/561, 52/562, 563, 564, 568, 569, 570, 571, 572, 52/582.1, 587.1, 586.1, 586.2, 585.1, 604, 52/589.1, 890.2, 590.3, 591.1, 591.2, 591.3, 52/591.4, 591.5; 446/124, 125
See application file for complete search history.

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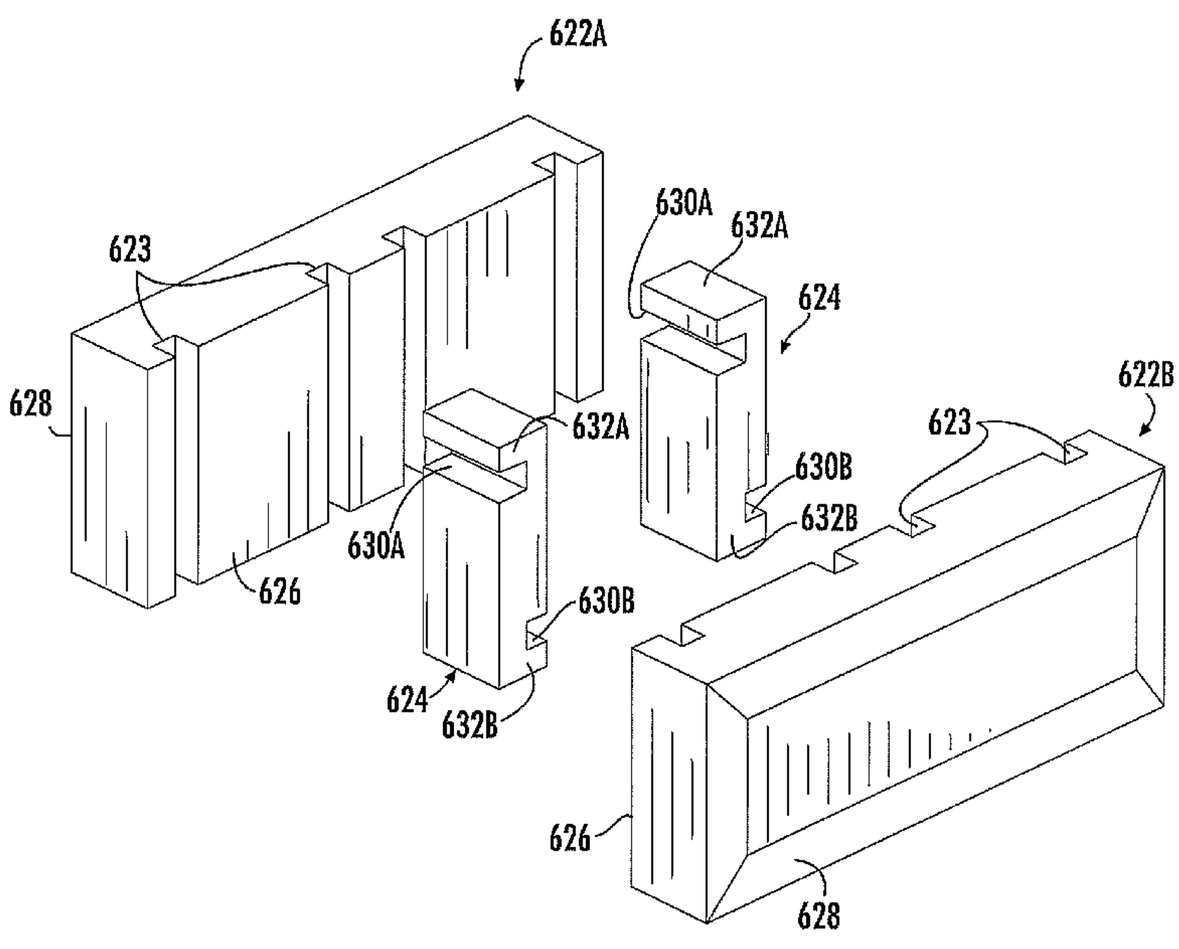
Primary Examiner — Jessica Laux
(74) *Attorney, Agent, or Firm* — Shumaker, Loop & Kendrick, LLP

(57) **ABSTRACT**

A modular block apparatus includes first and second blocks, each block having a generally upwardly protruding locking member and an internal recess sized to receive the locking member of the other block, such that the blocks can be assembled with one block above the other. The blocks are secured together in a vertical direction by relative lateral movement of the locking member and the internal recess. A locking device is provided to prevent relative lateral movement of the locking member and the internal recess so as to retain the blocks in a connected condition. The locking member may be an integral hook, a separate hook, or a cylindrical locking rod. If a hook is used, its orientation relative to the block may be varied. A variety of structures may be built up from the modular blocks.

4 Claims, 41 Drawing Sheets



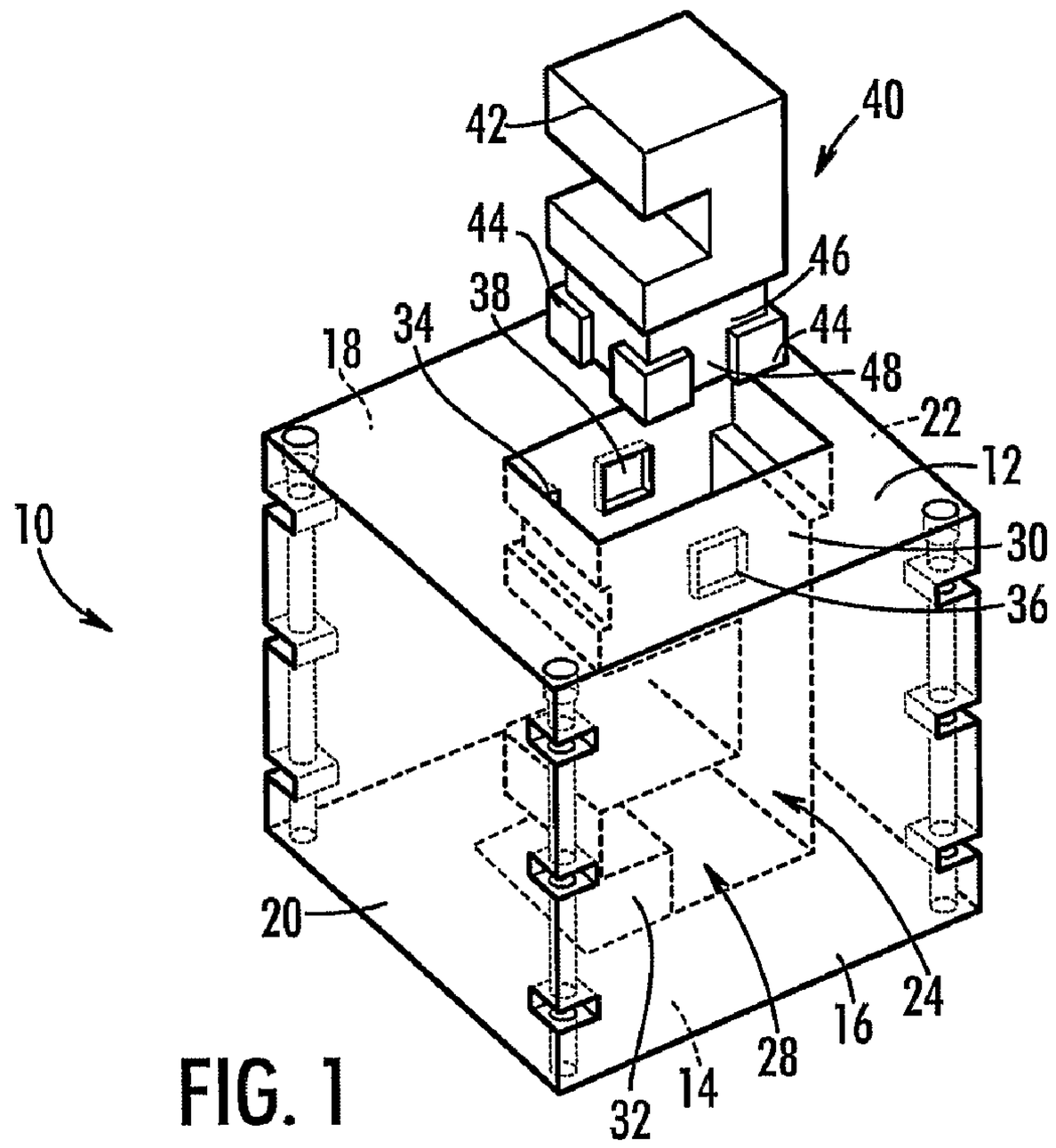

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FIG. 1

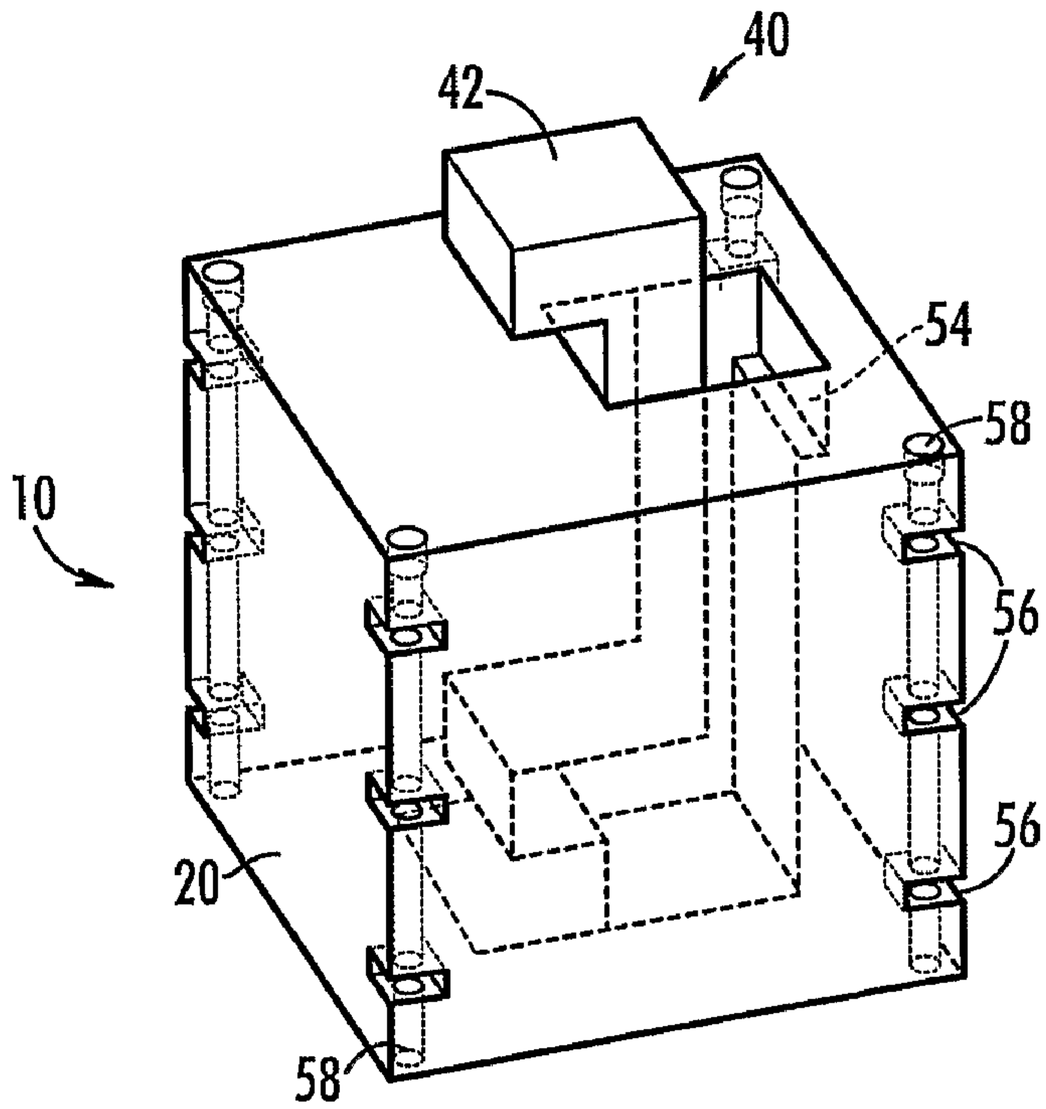
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FIG. 2

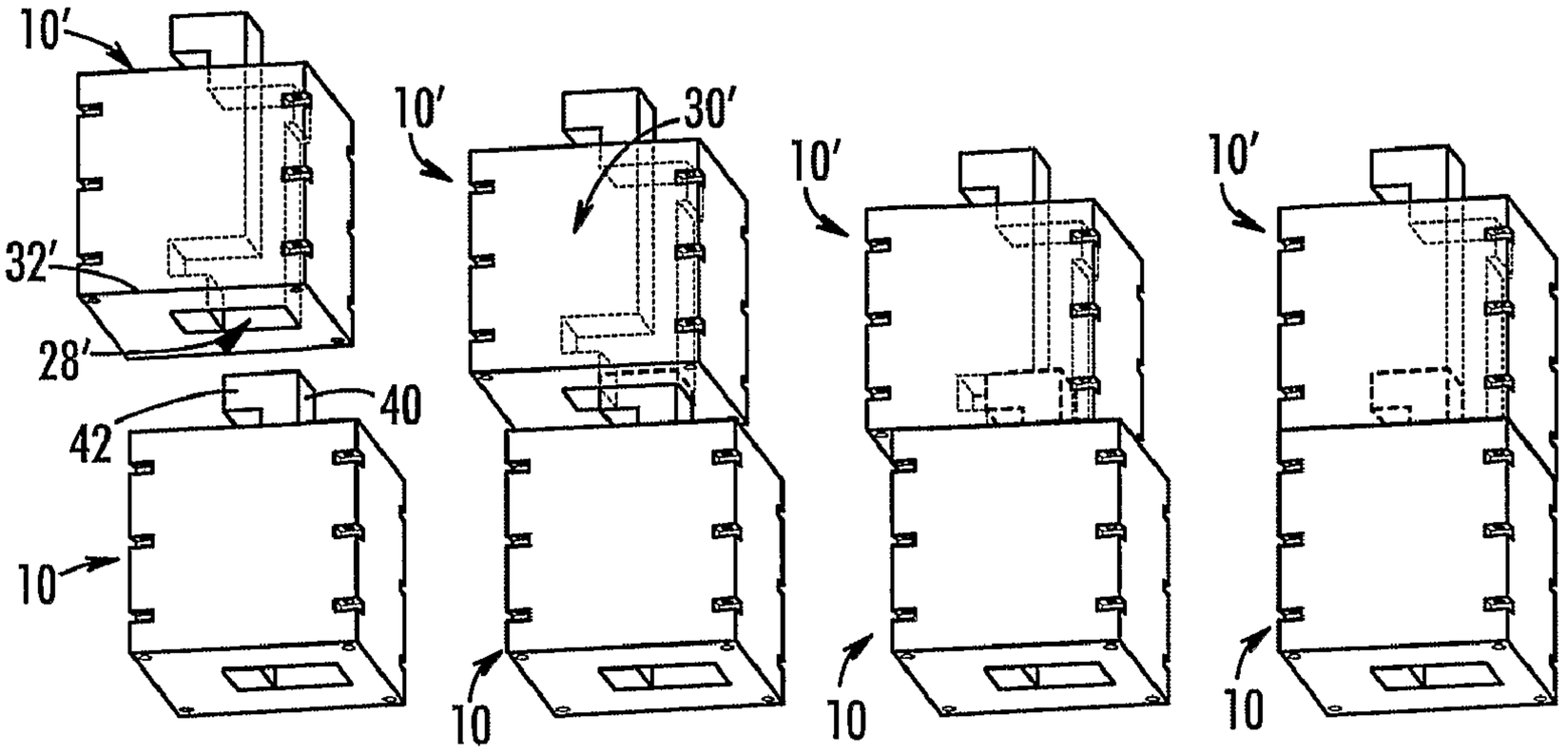


FIG. 3A FIG. 3B FIG. 3C FIG. 3D

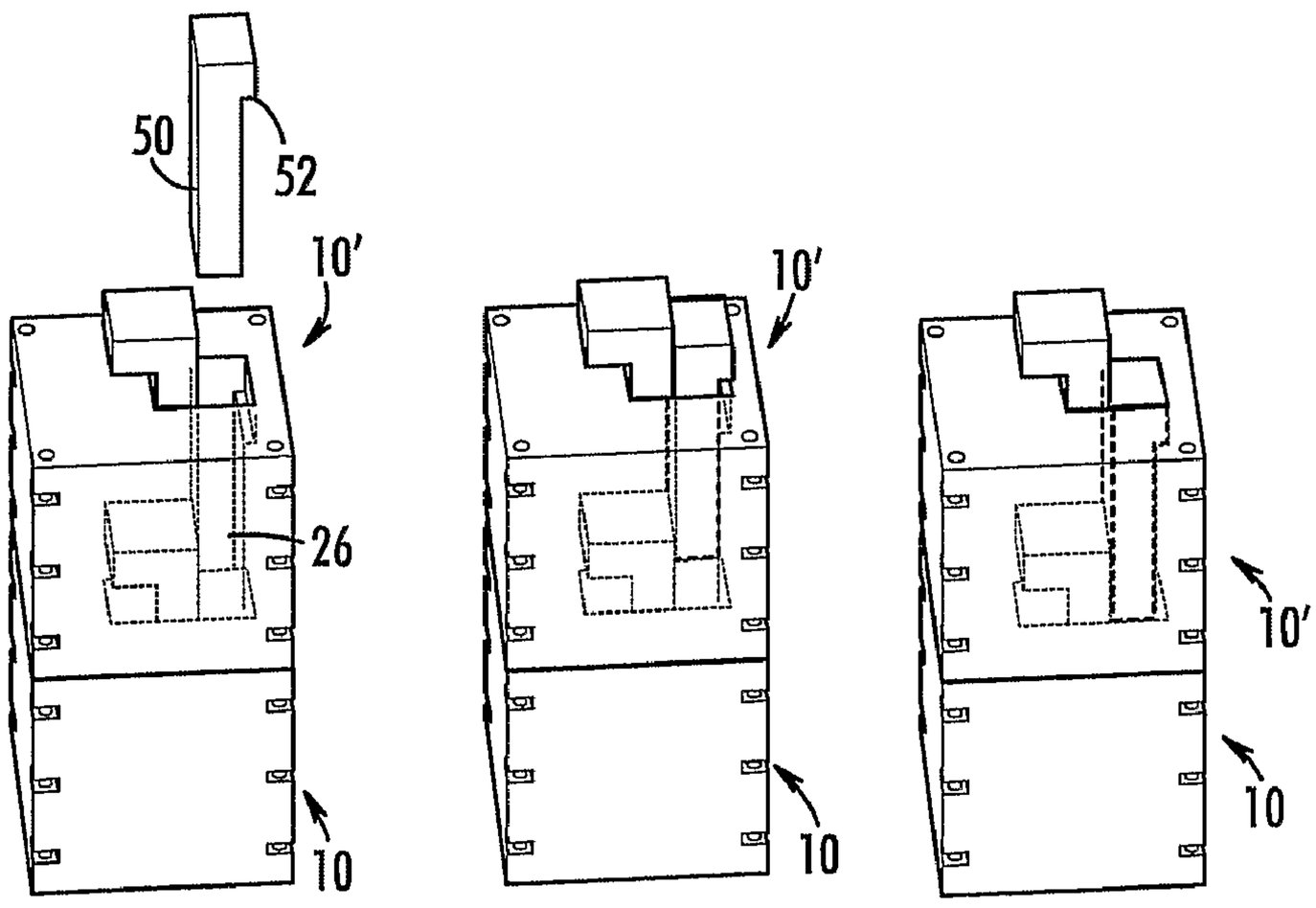
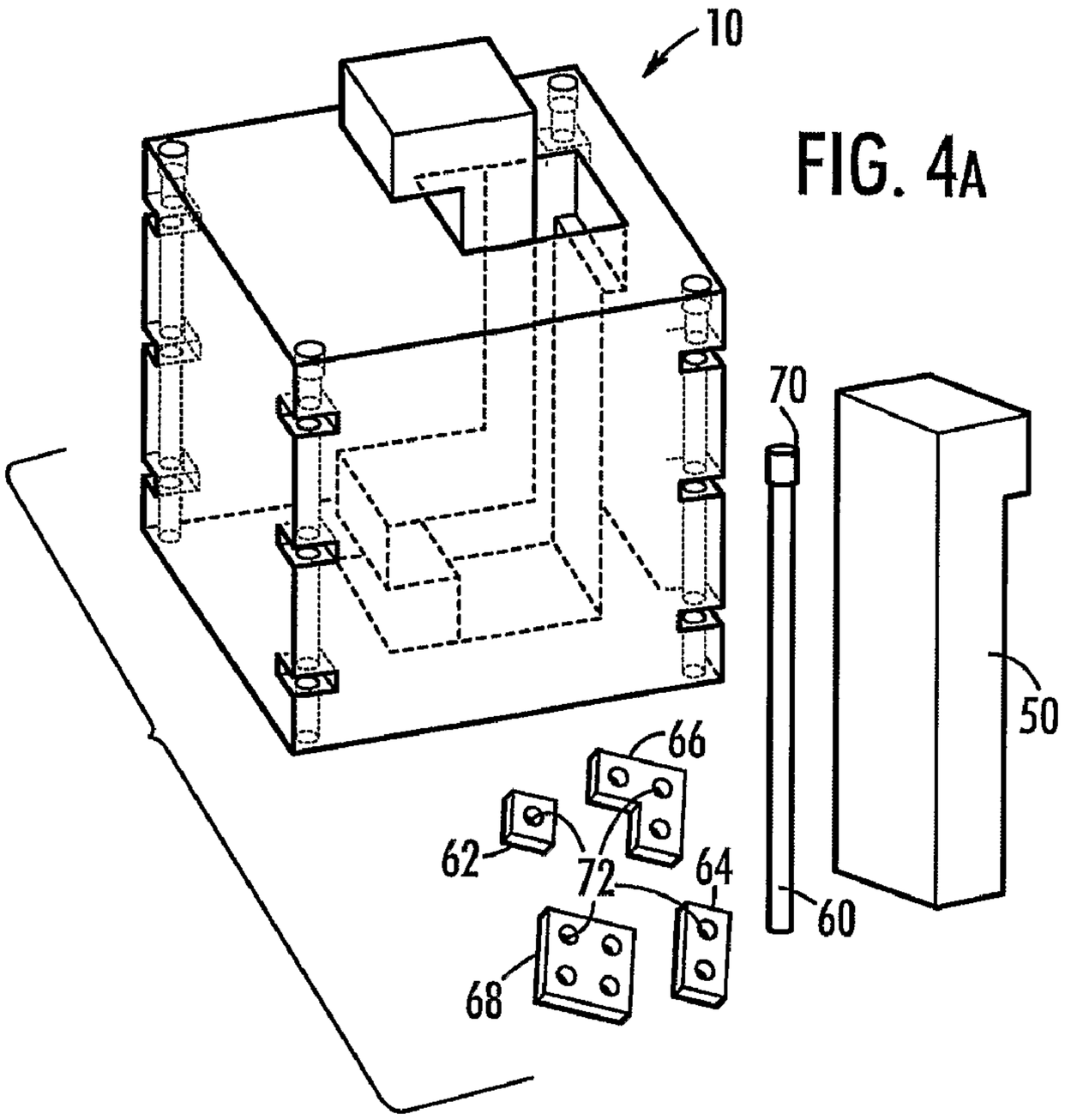


FIG. 3E FIG. 3F FIG. 3G



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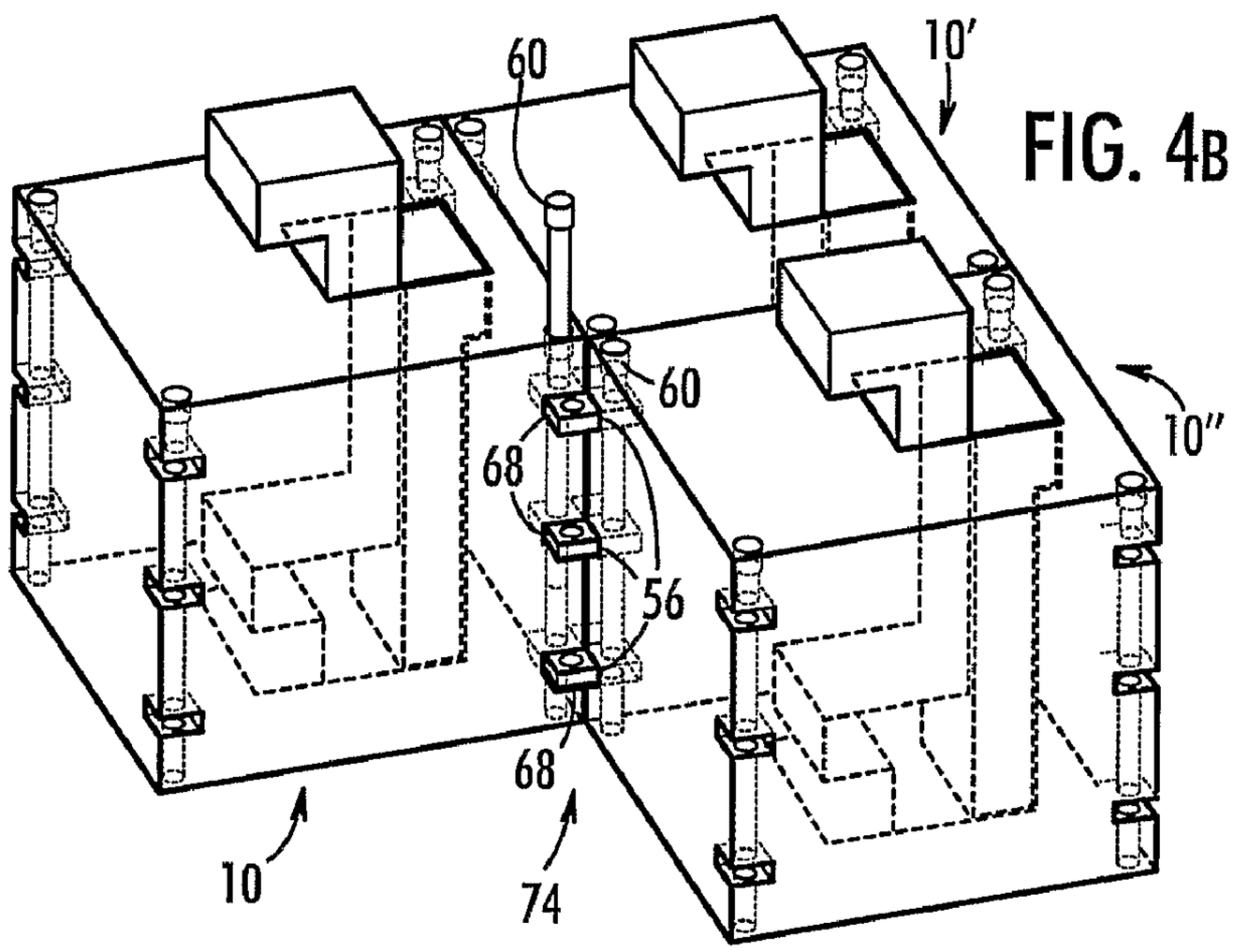


FIG. 4B

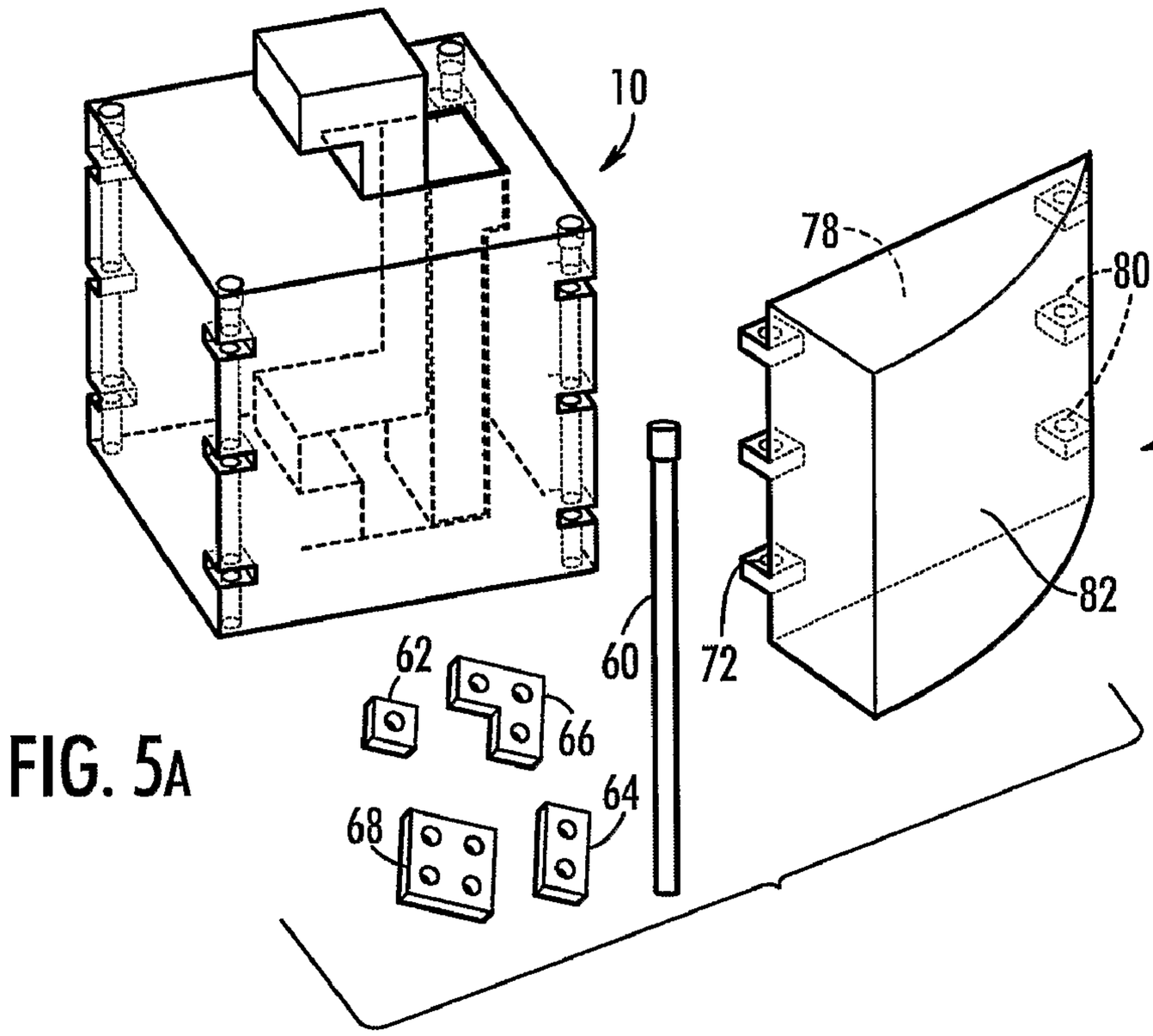


FIG. 5A

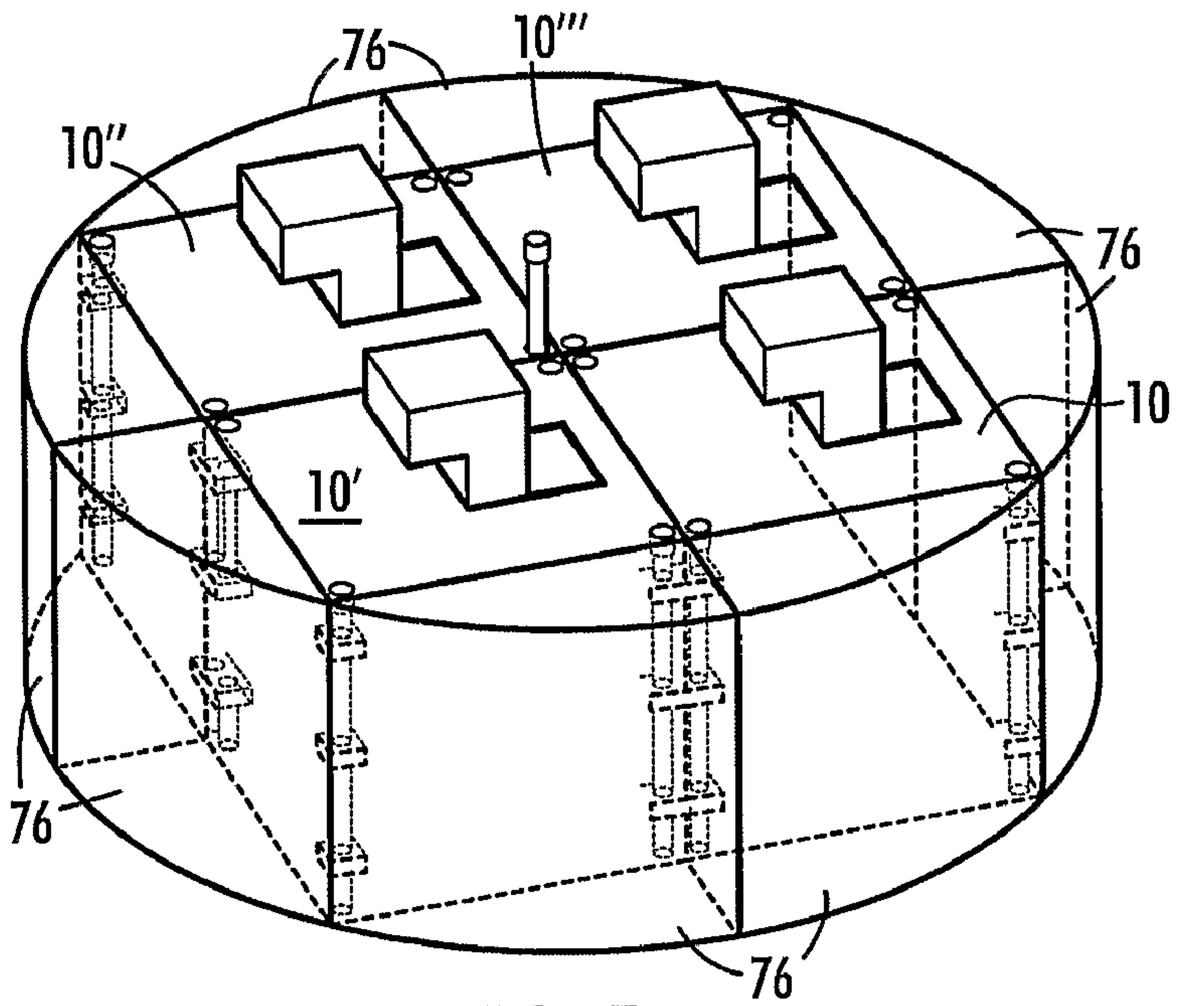
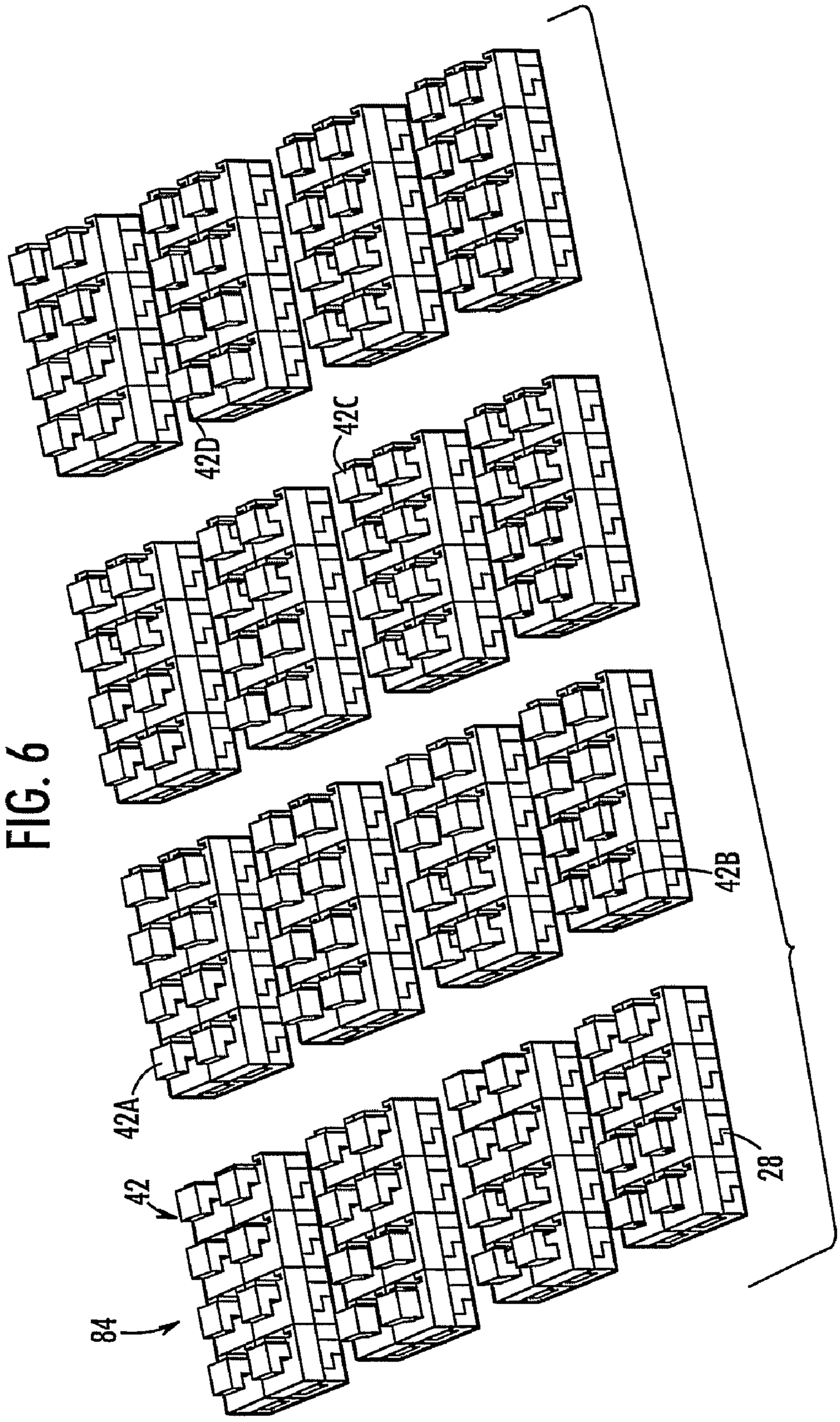
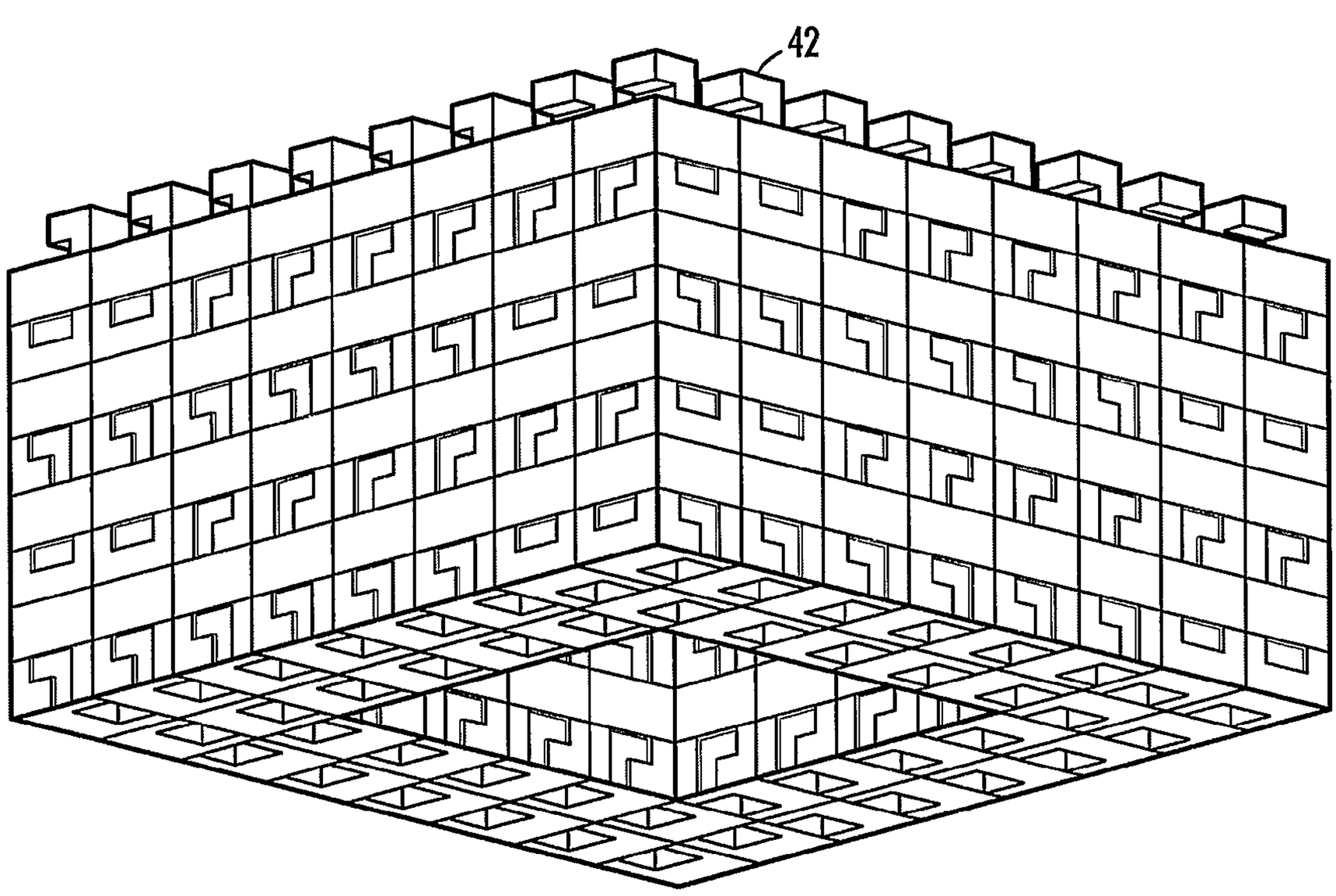


FIG. 5B

FIG. 6





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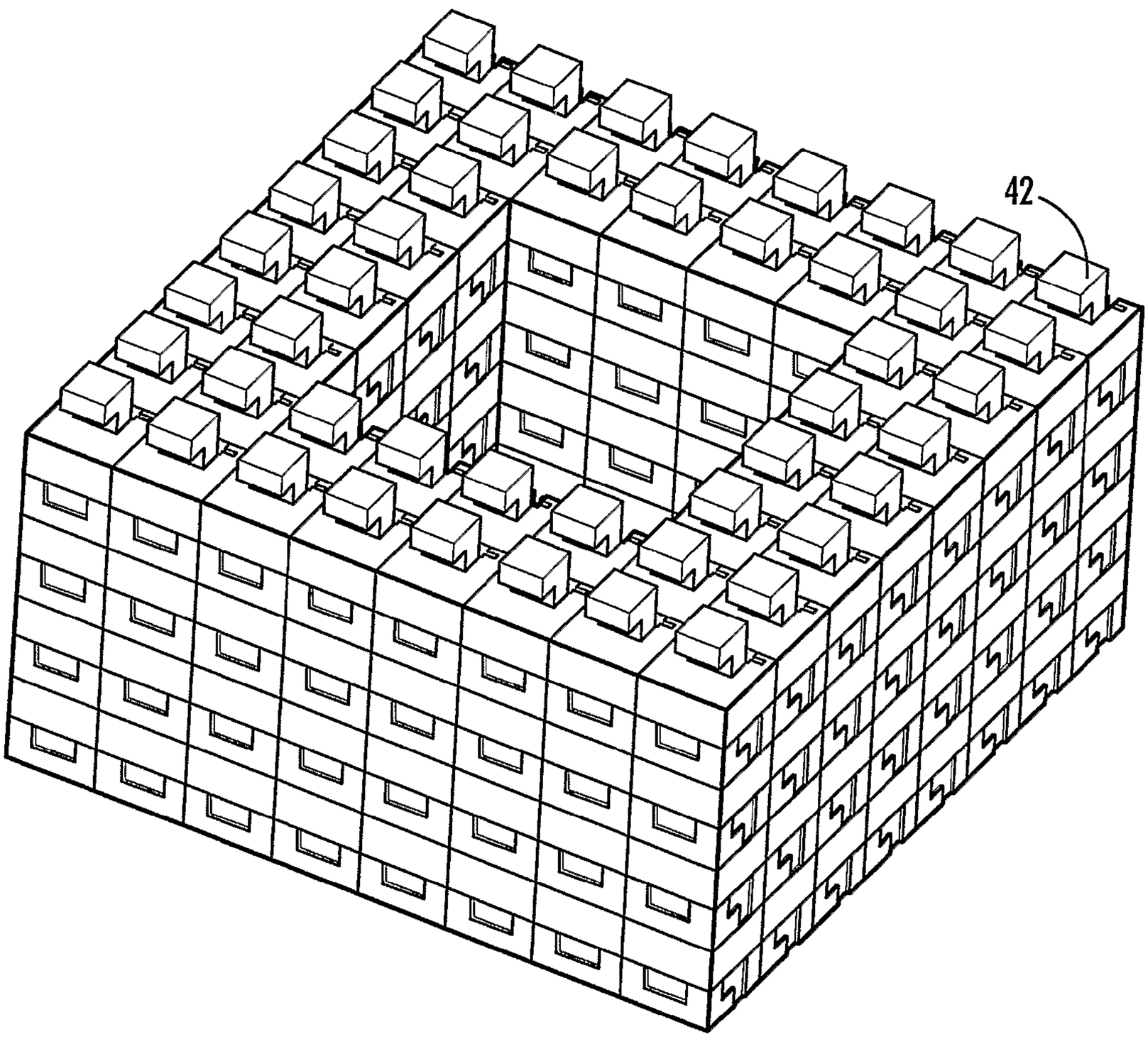

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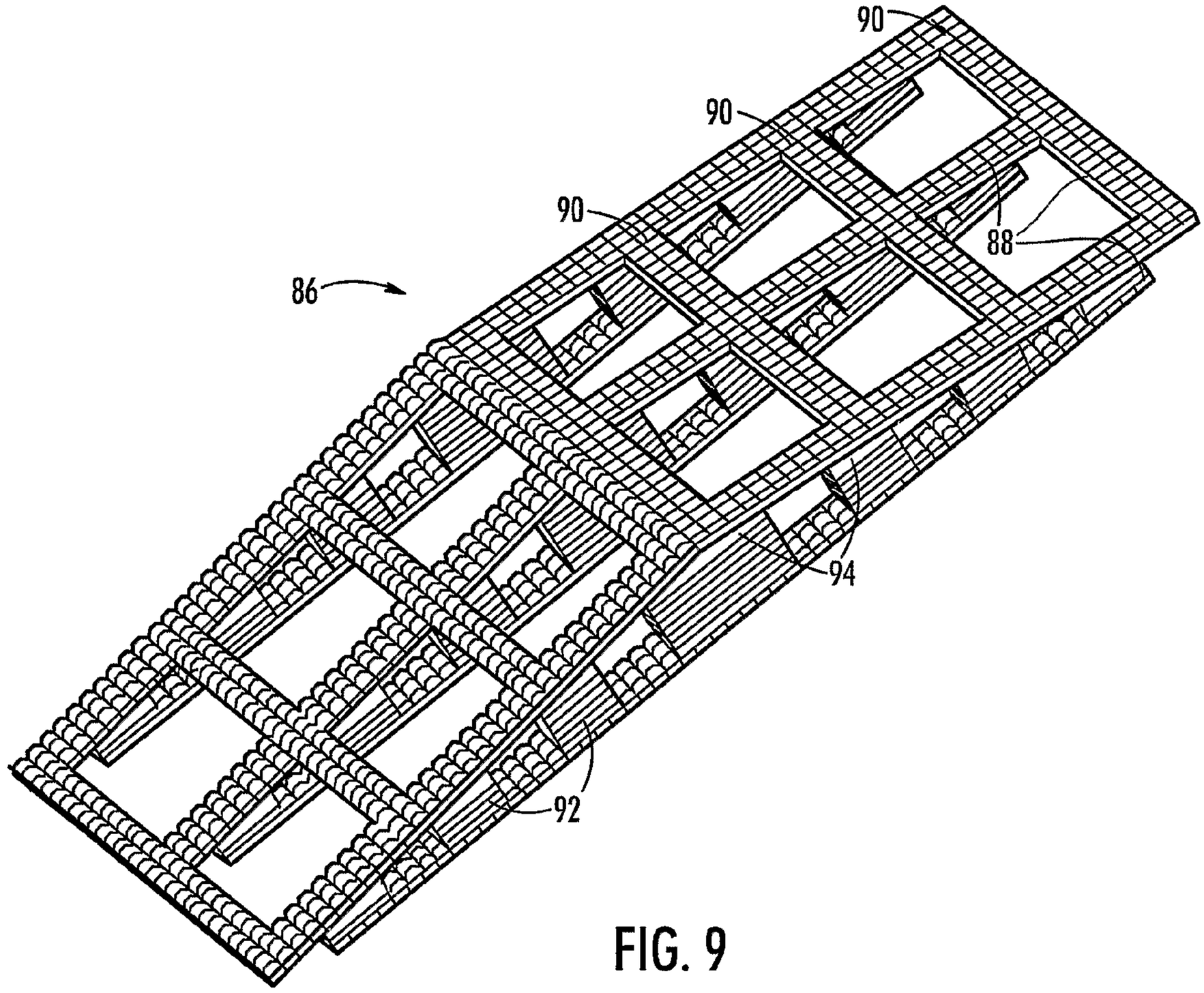
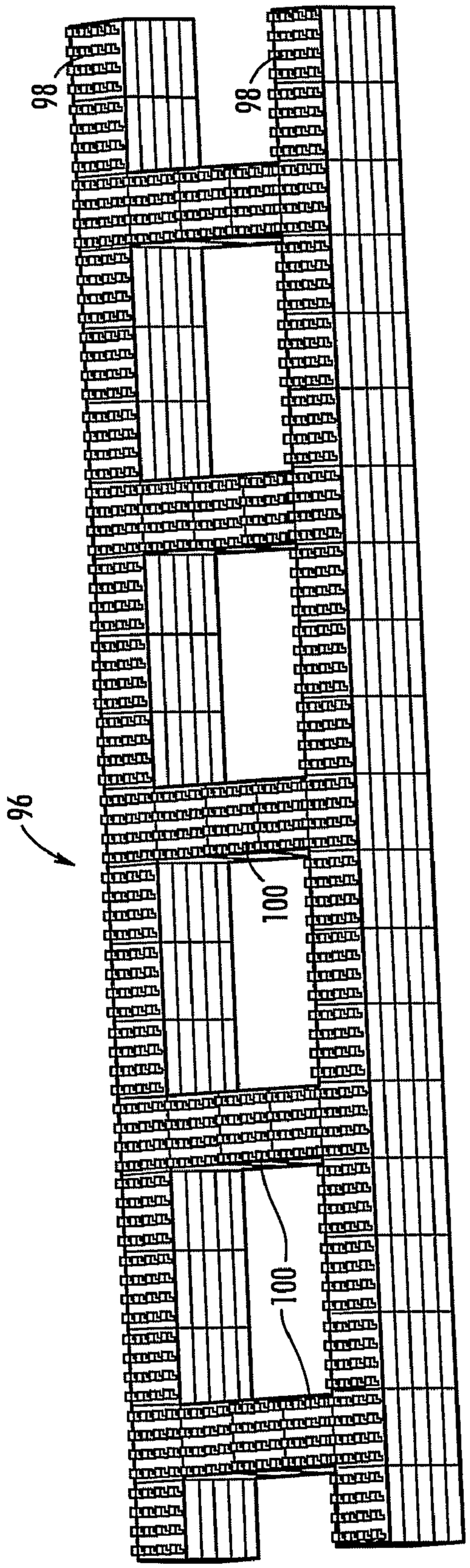


FIG. 9



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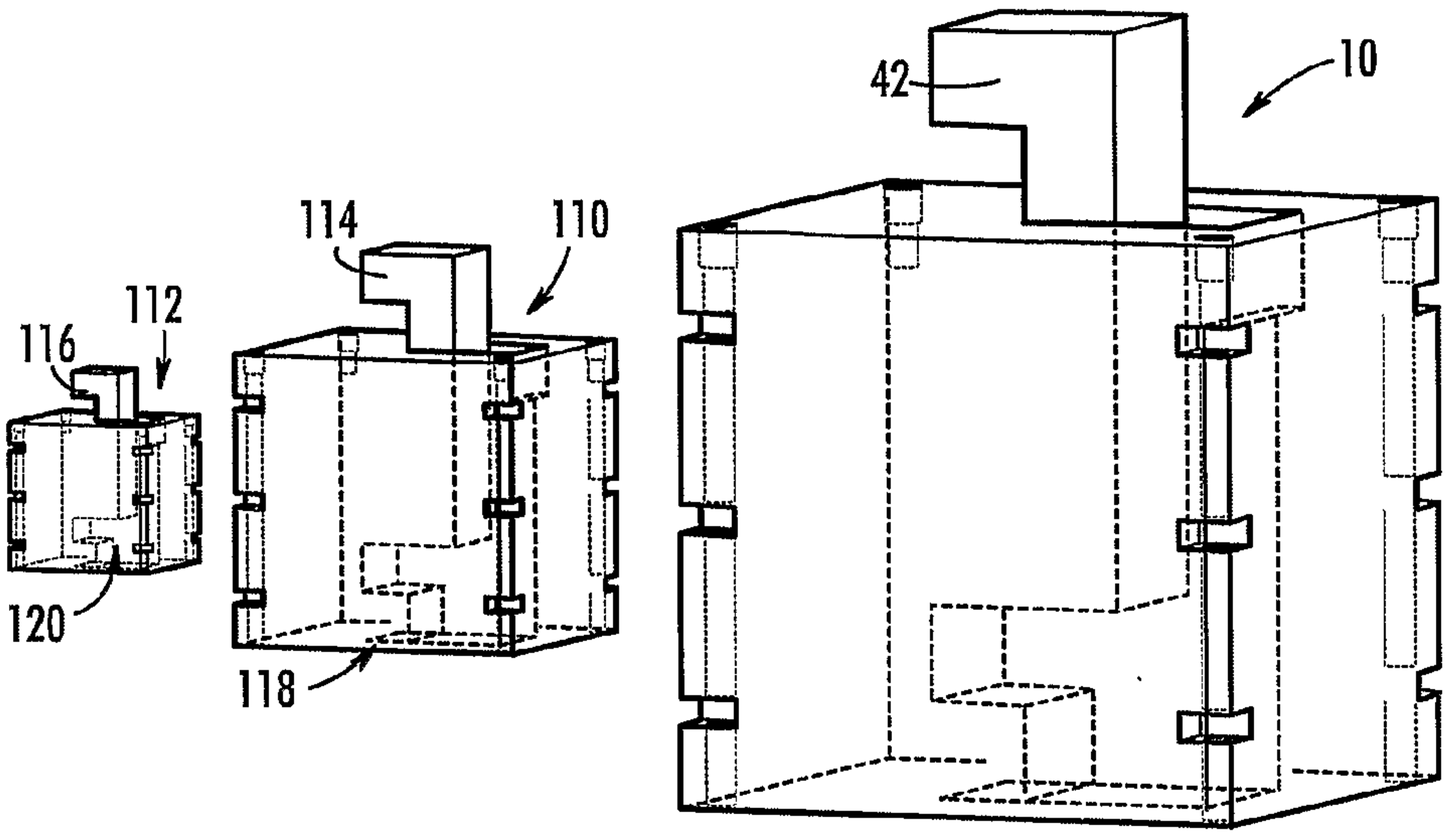


FIG. 11

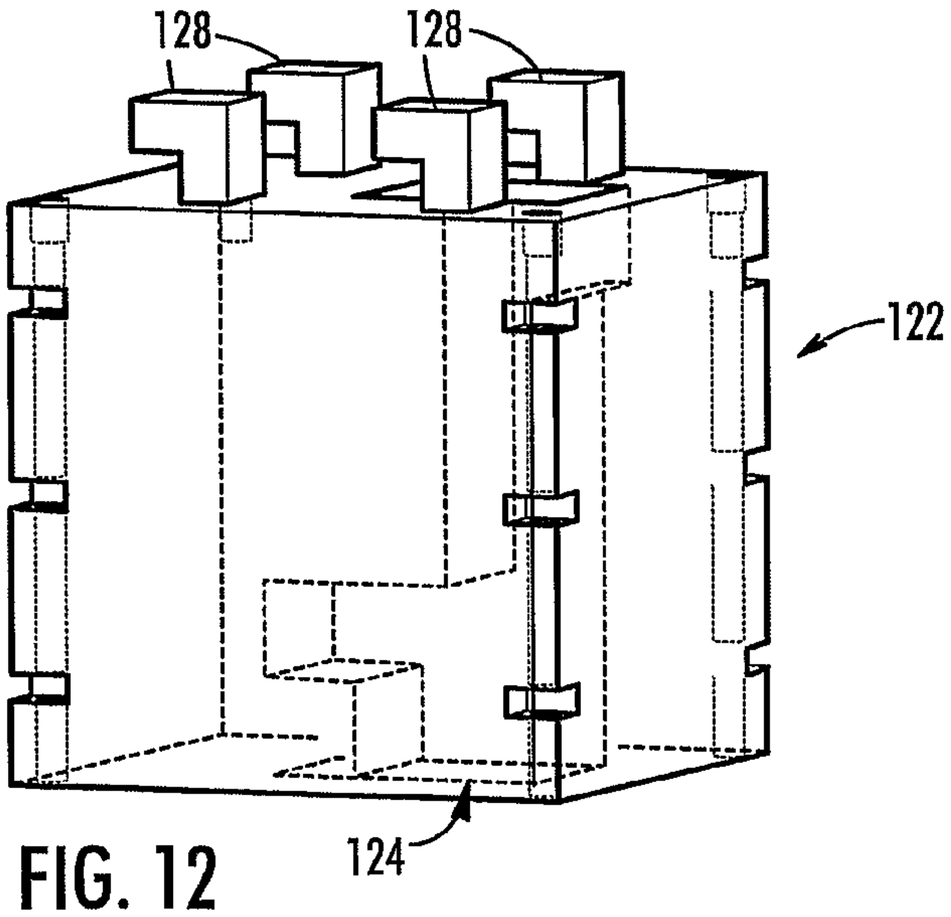


FIG. 12

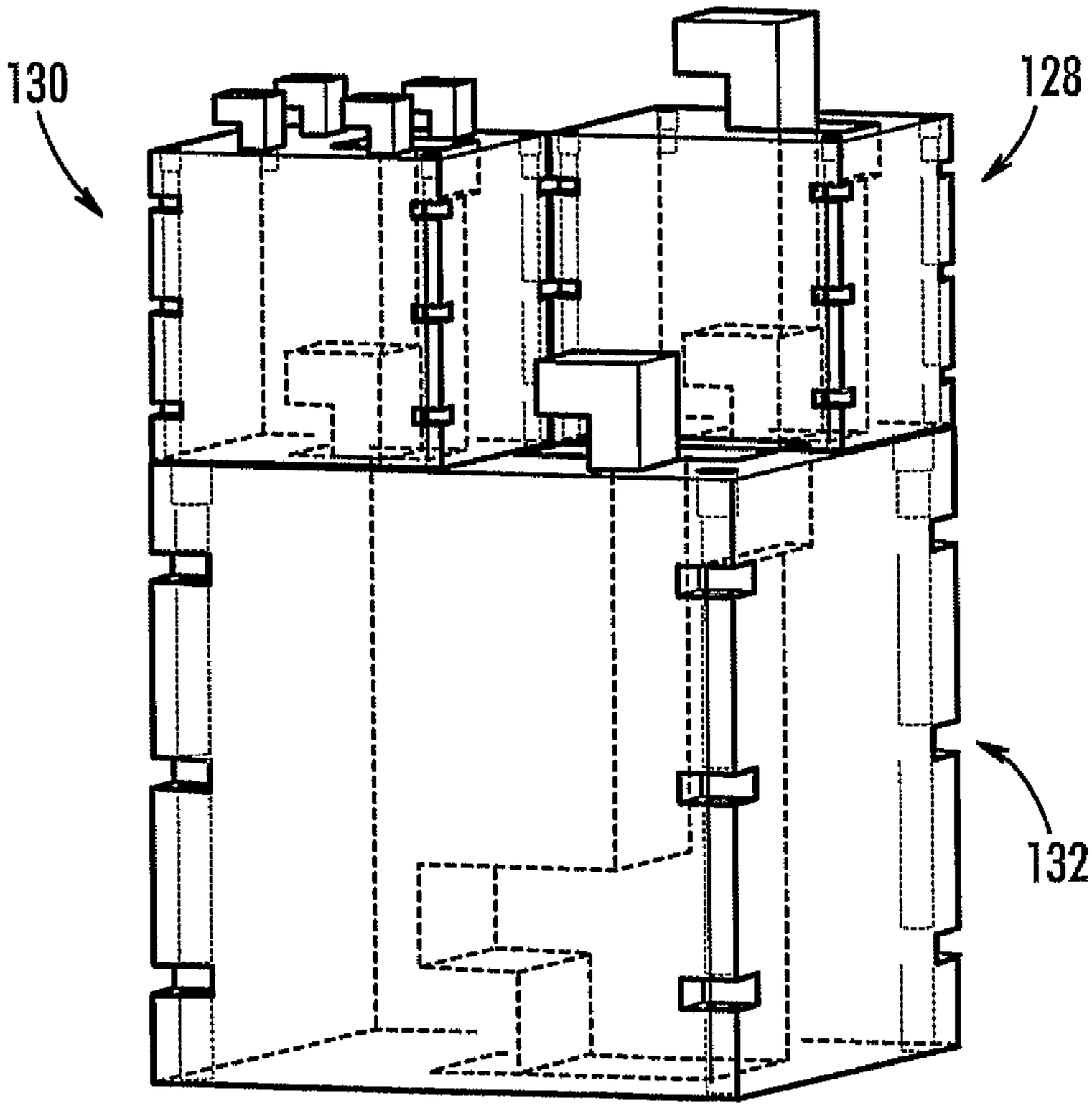
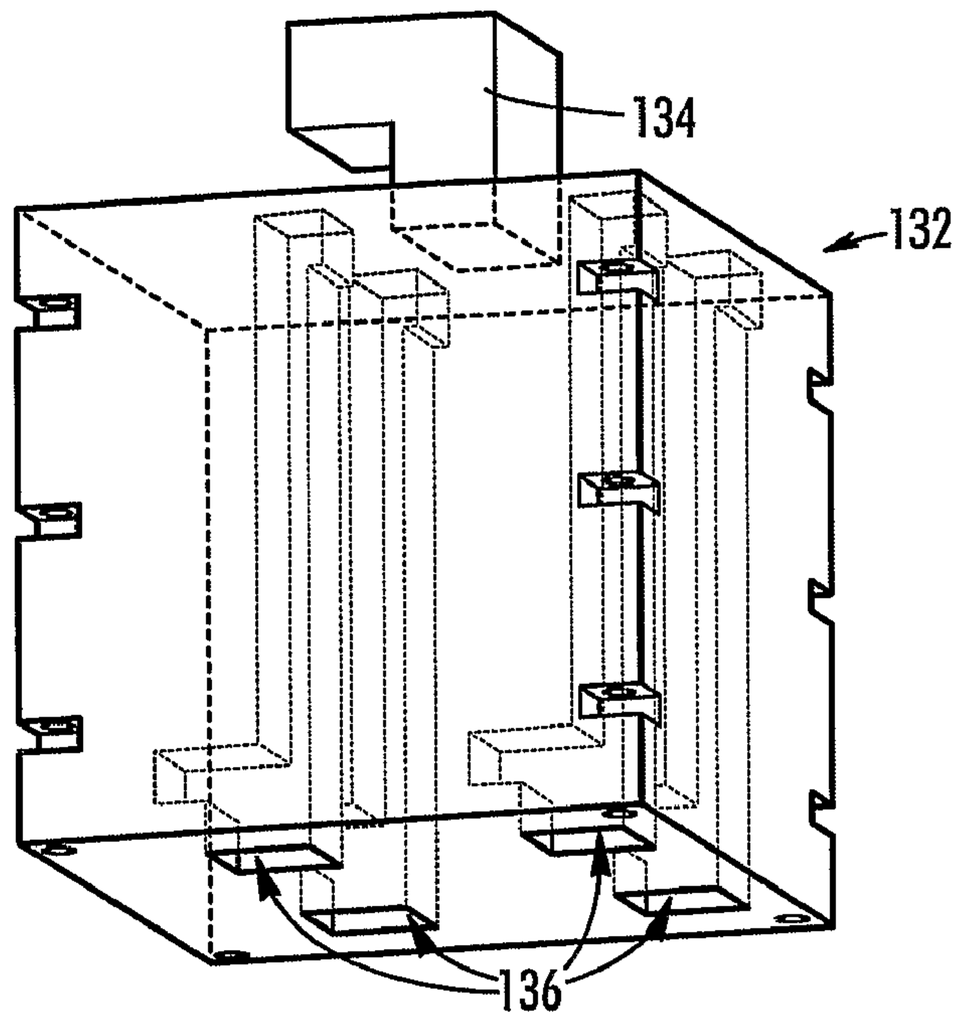


FIG. 13



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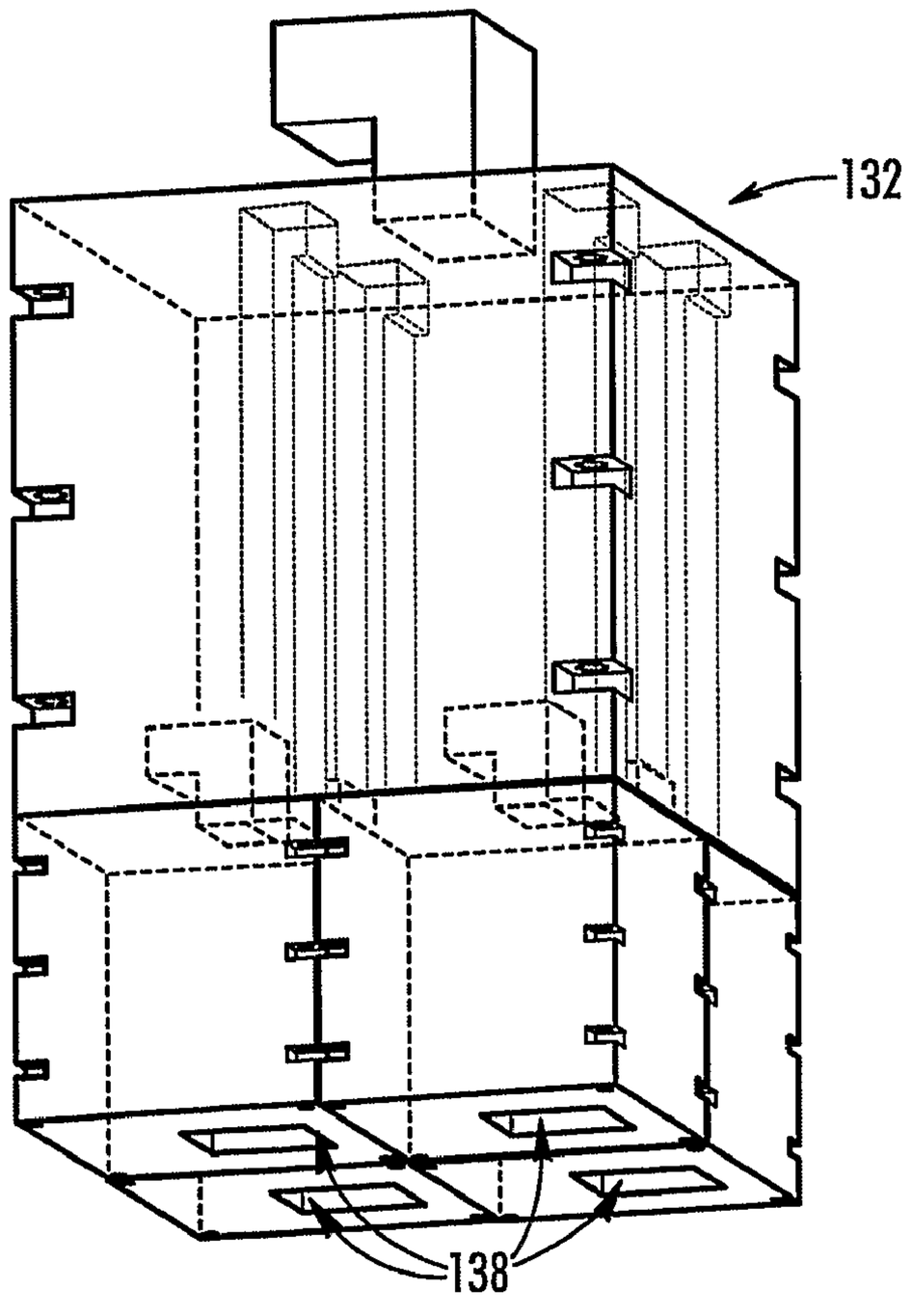

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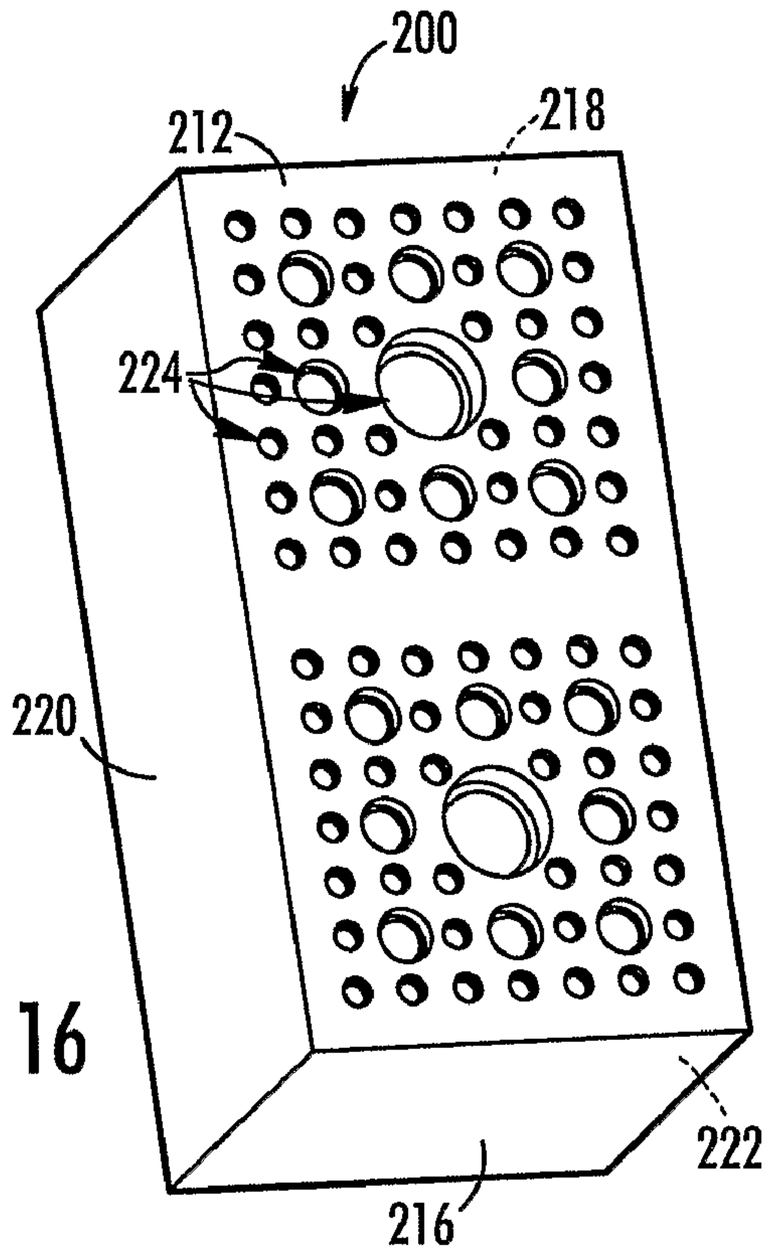
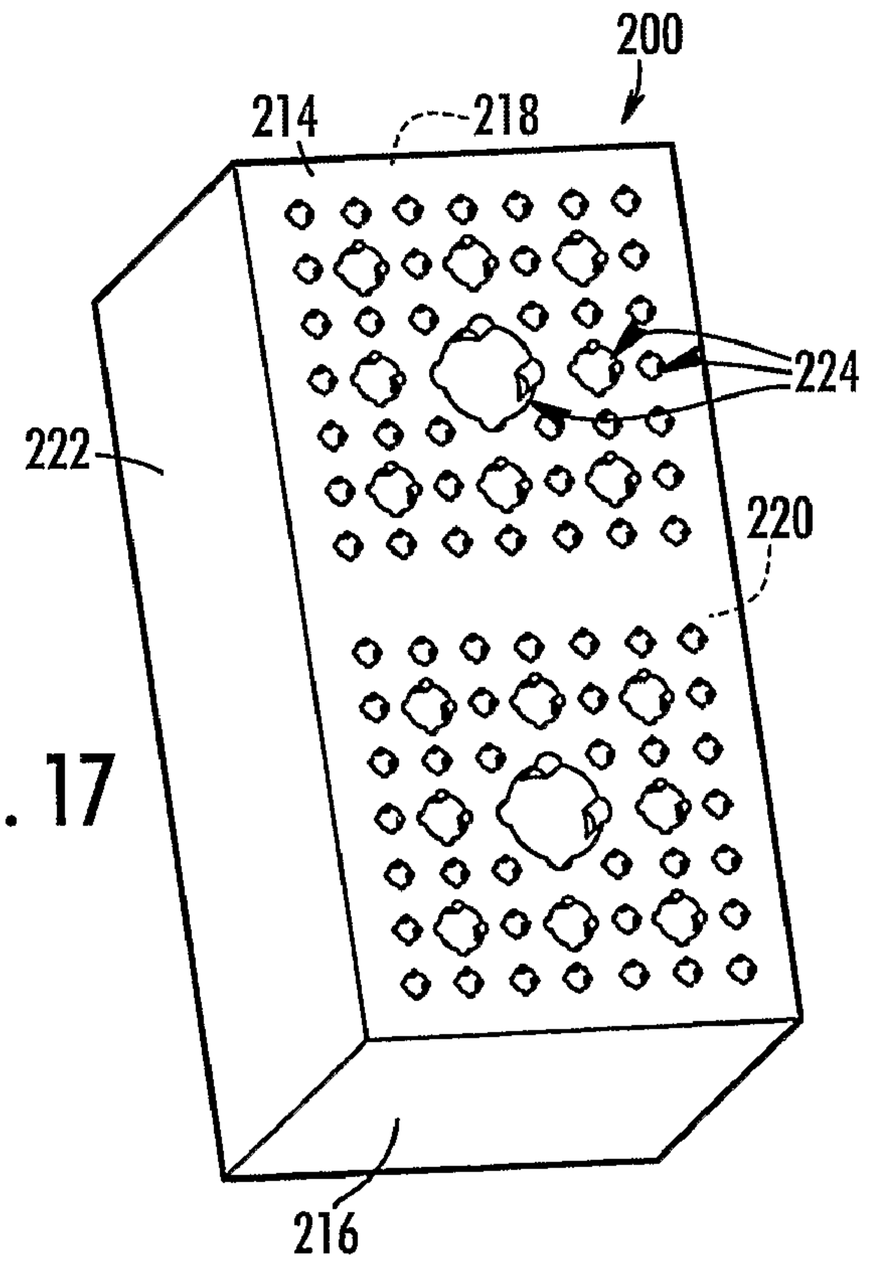


FIG. 16



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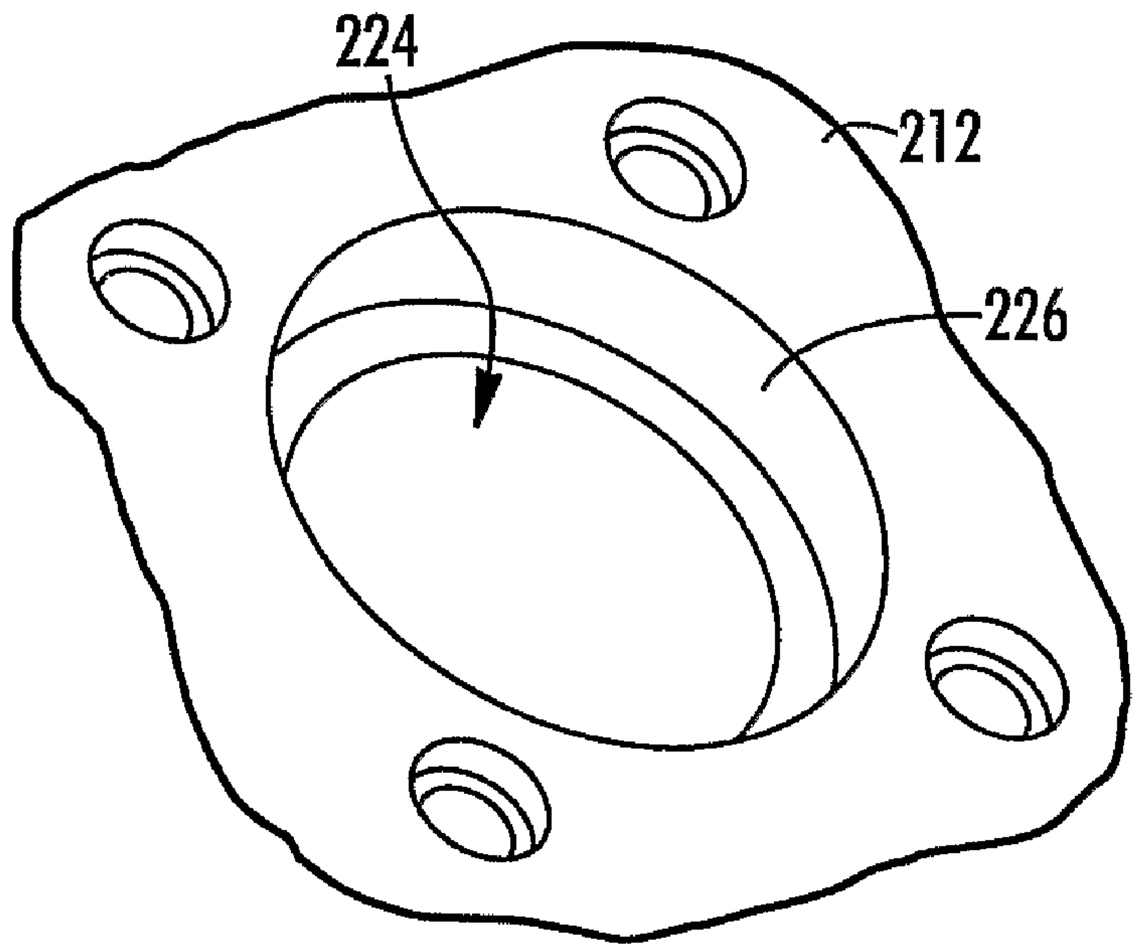
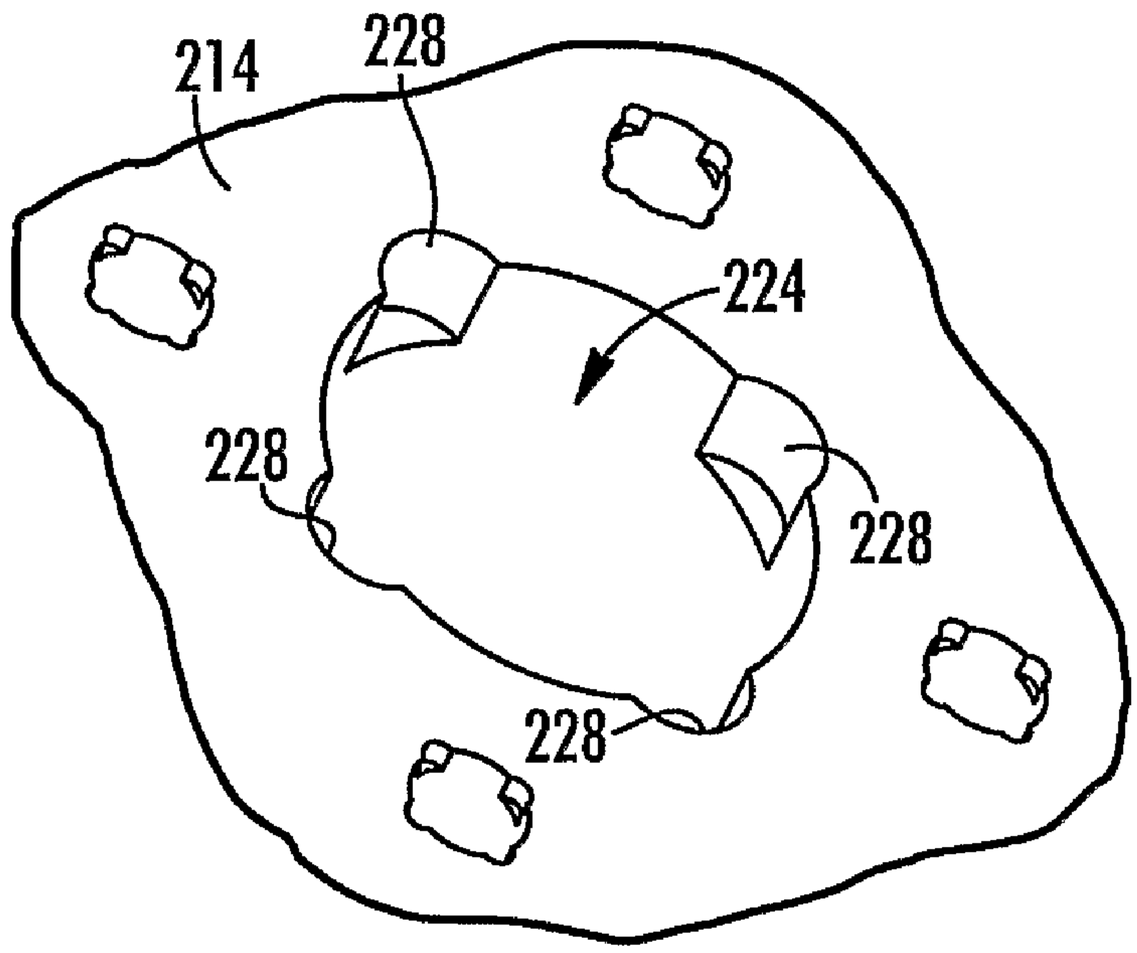


FIG. 18



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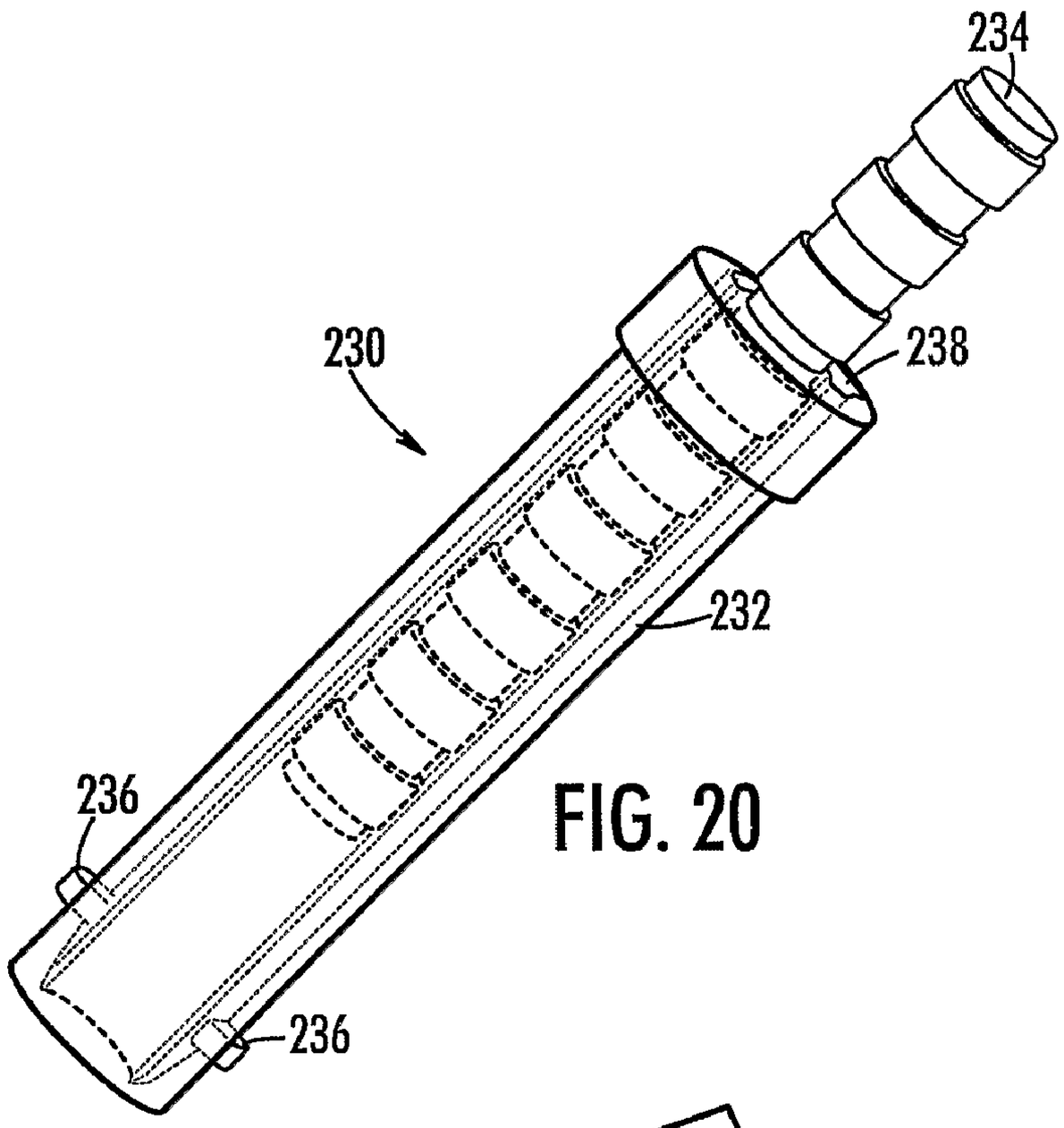


FIG. 20

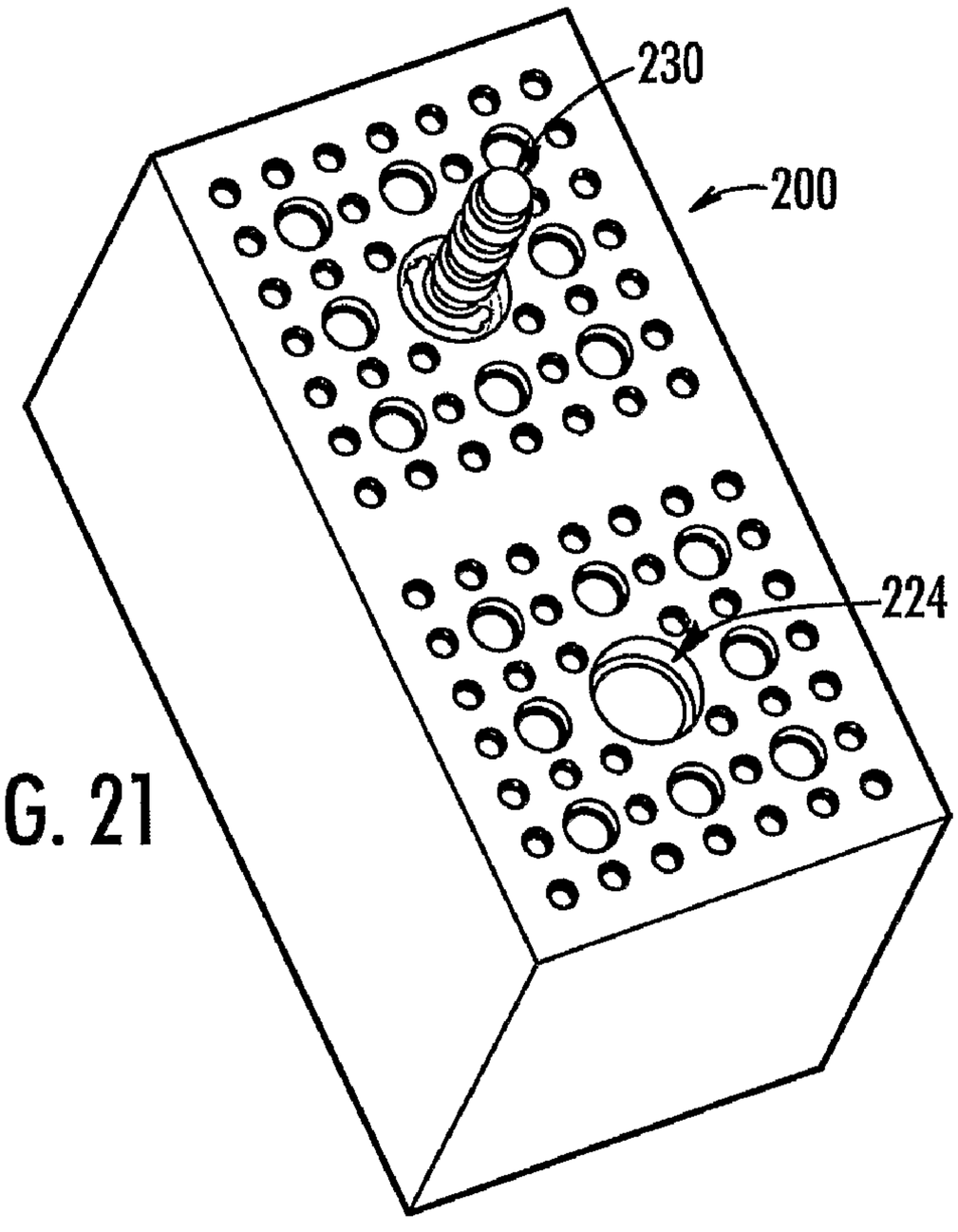
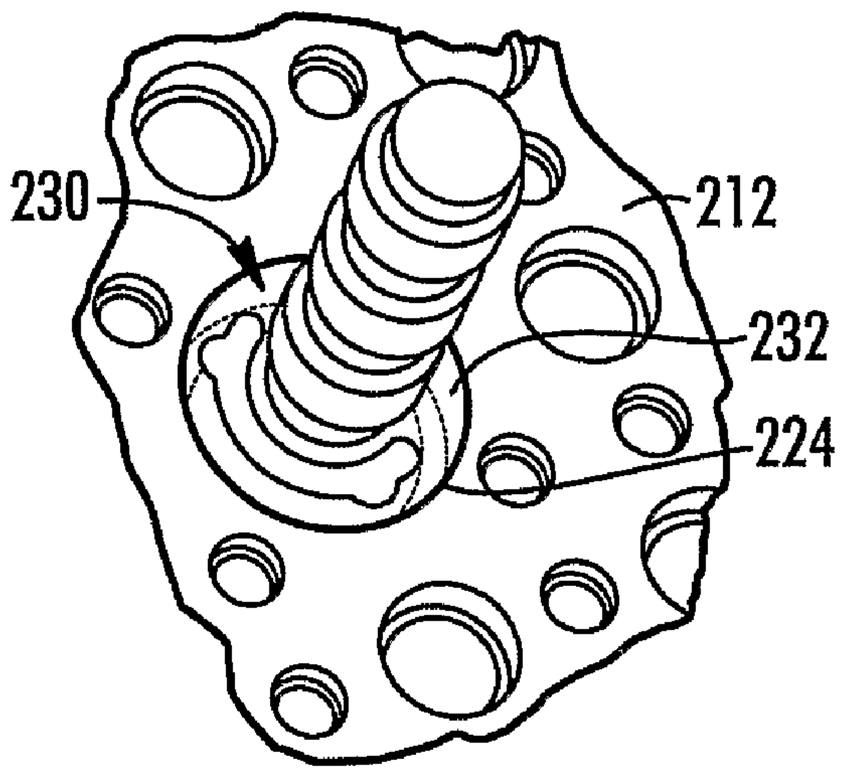


FIG. 21



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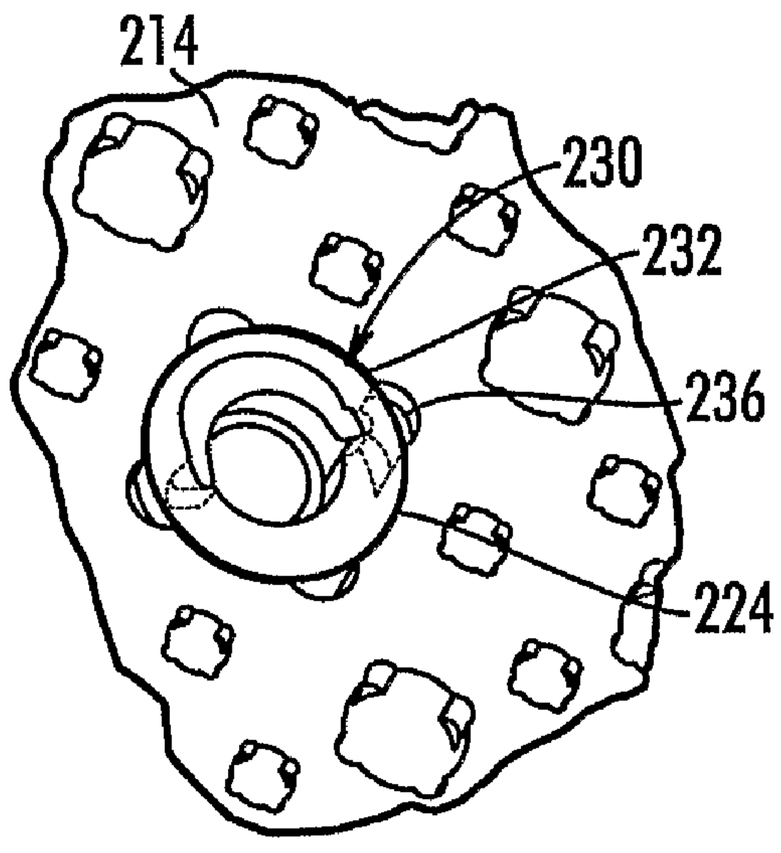


FIG. 23

FIG. 24A

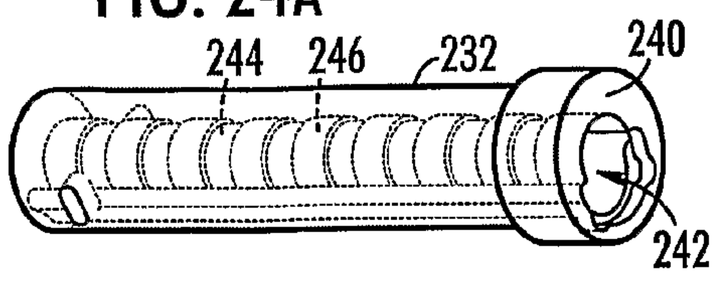


FIG. 24B

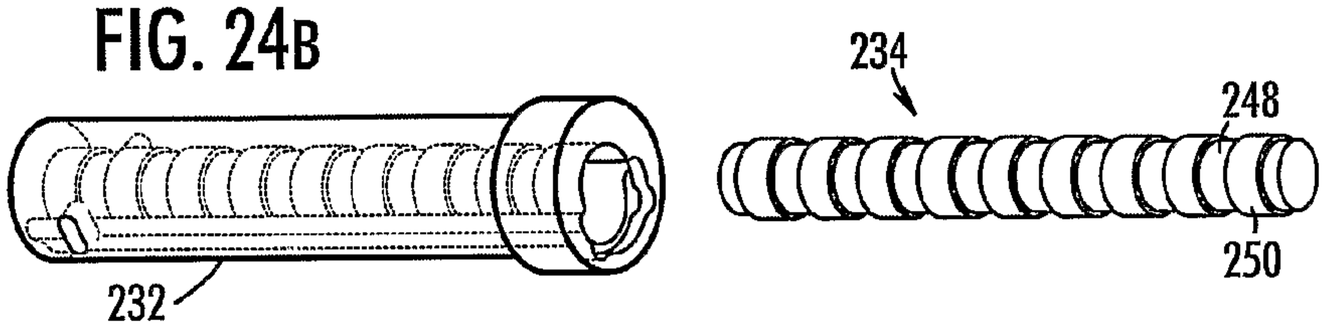


FIG. 24C

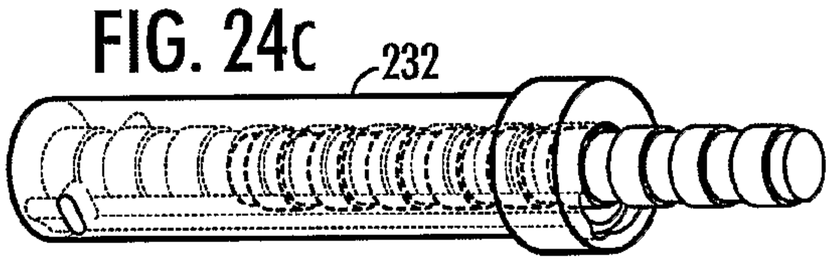


FIG. 24D

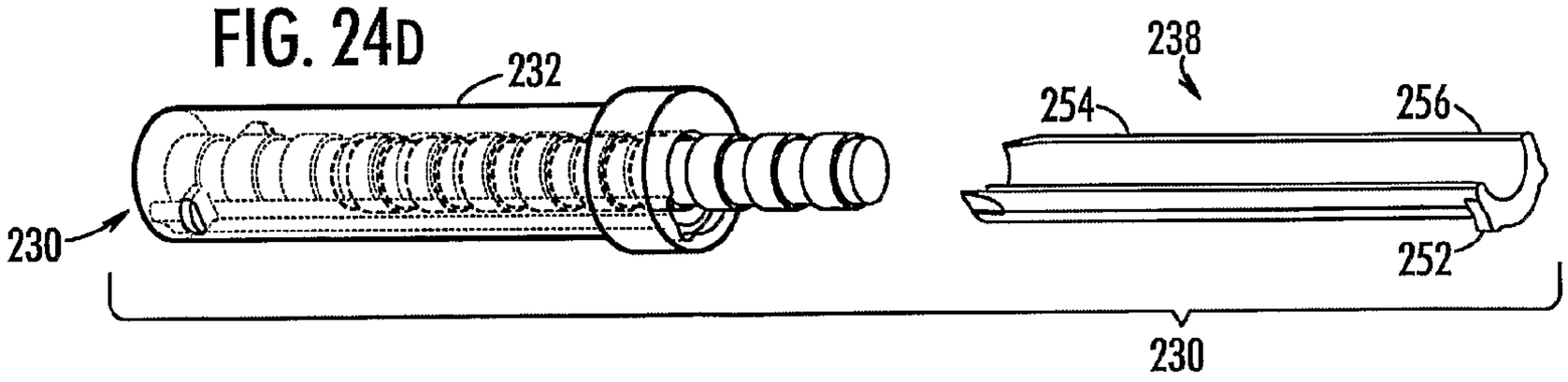
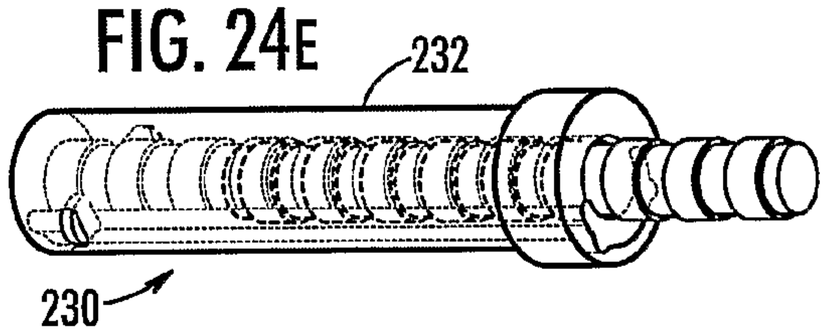


FIG. 24E



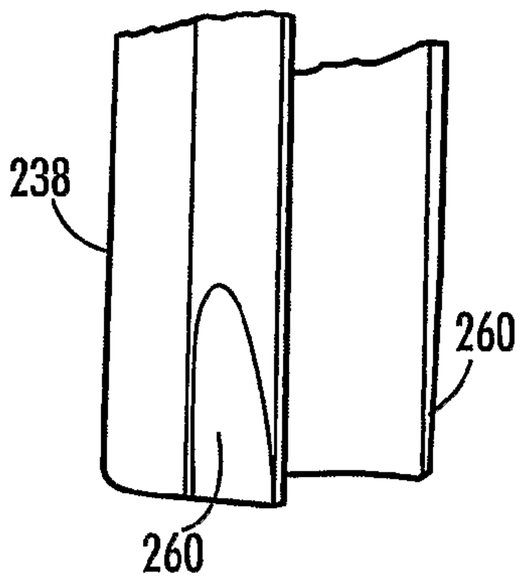
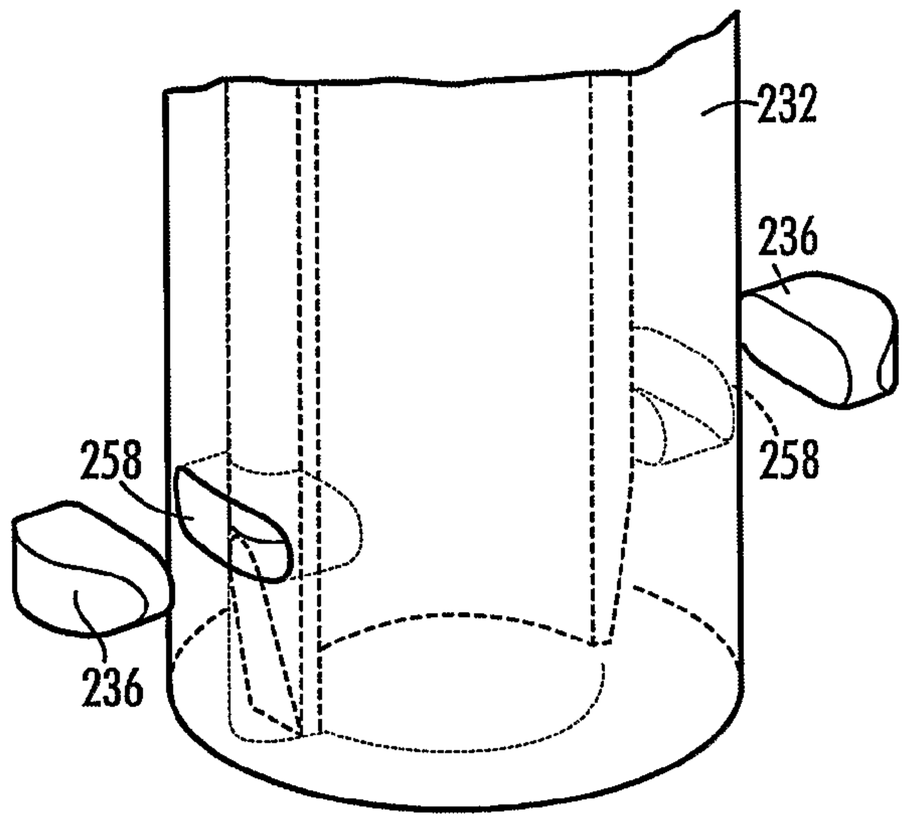


FIG. 25



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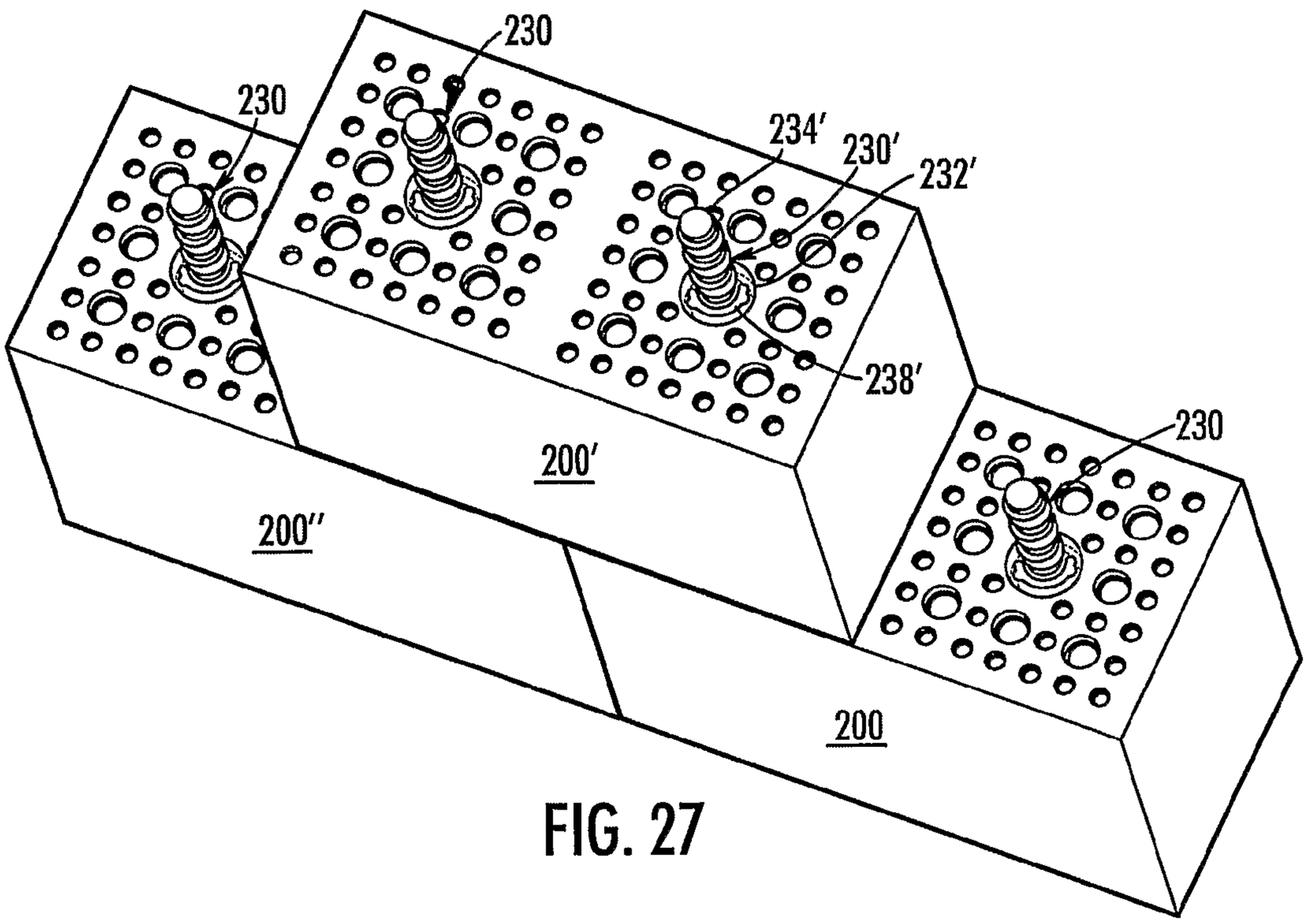

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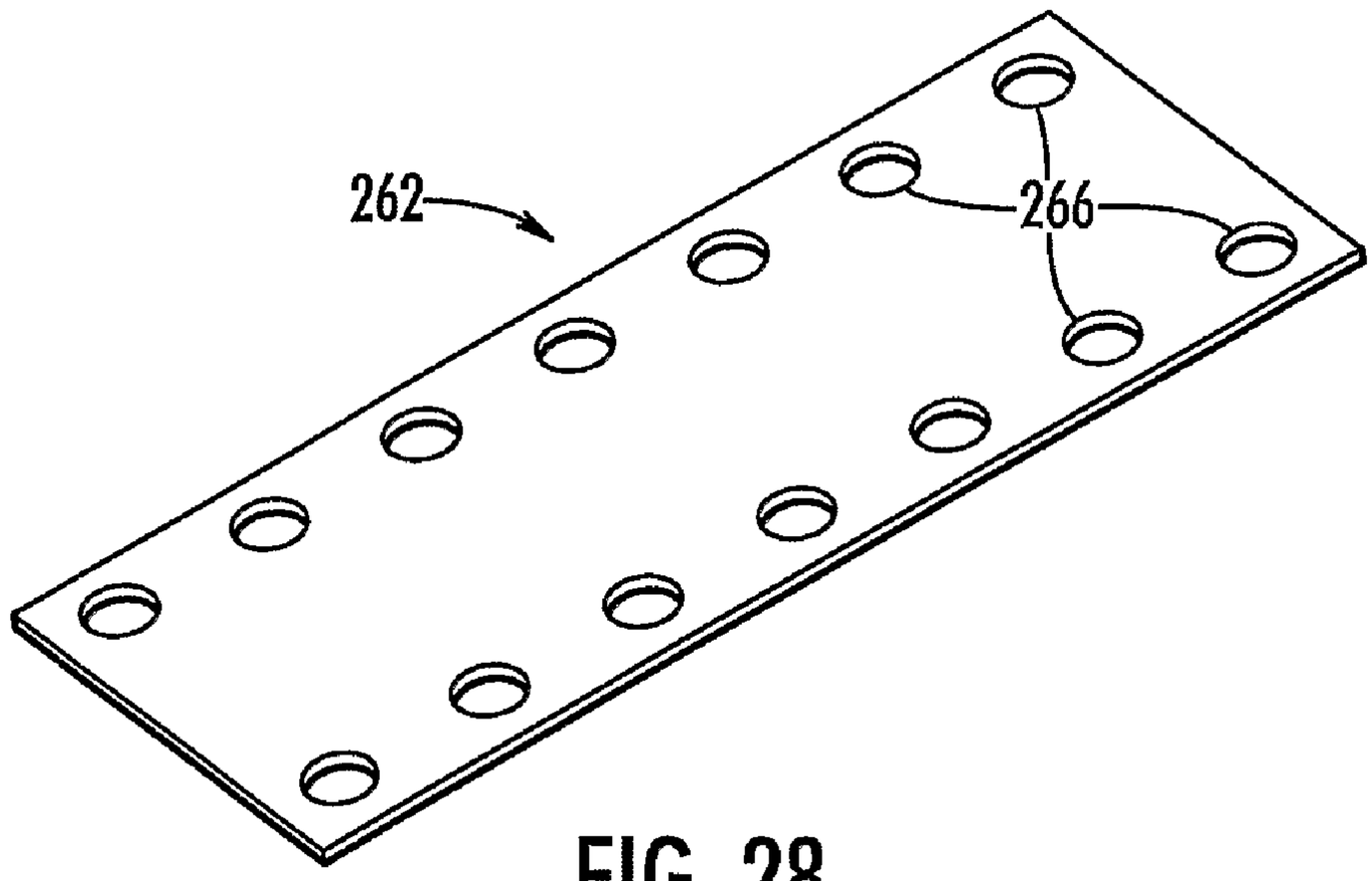

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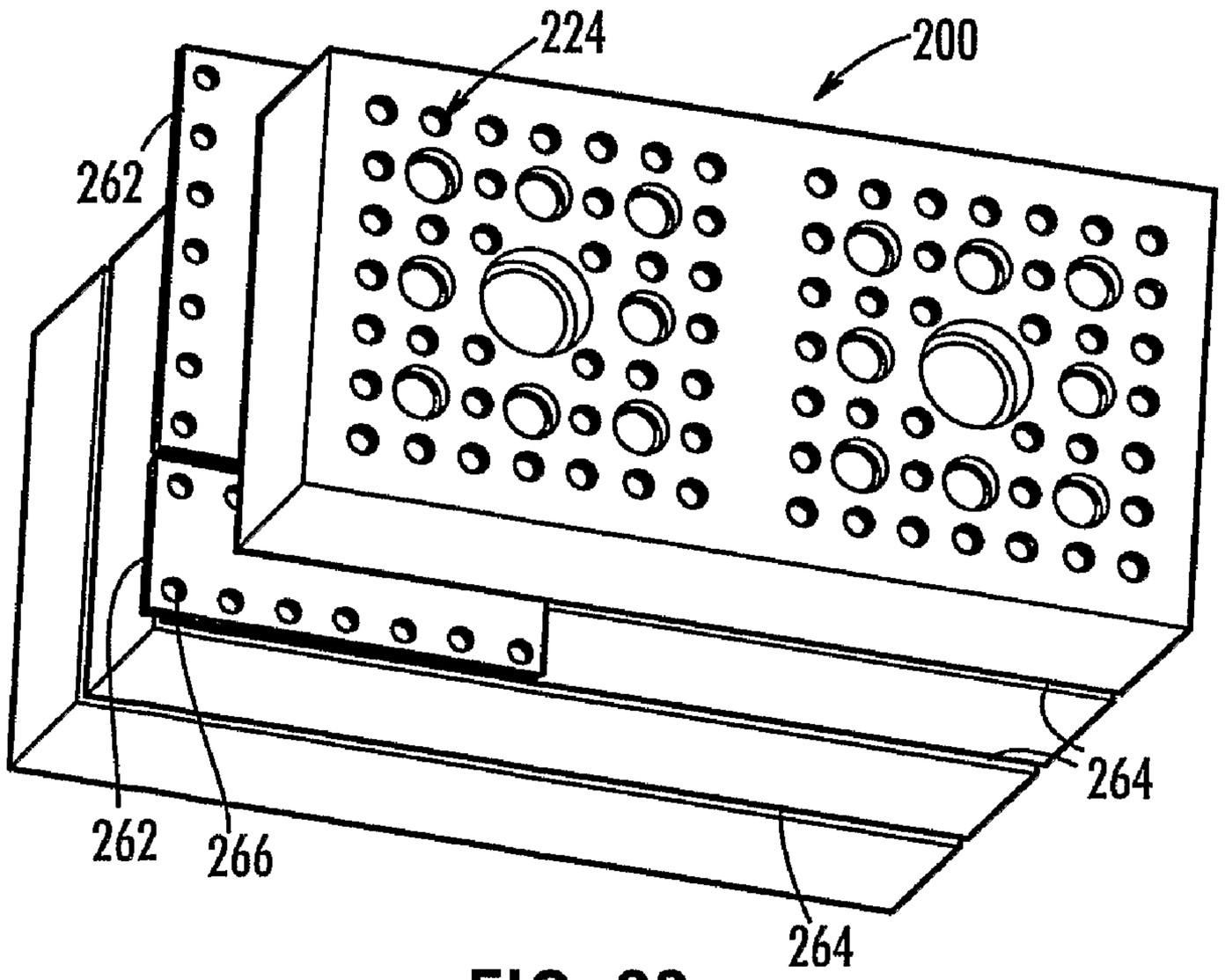

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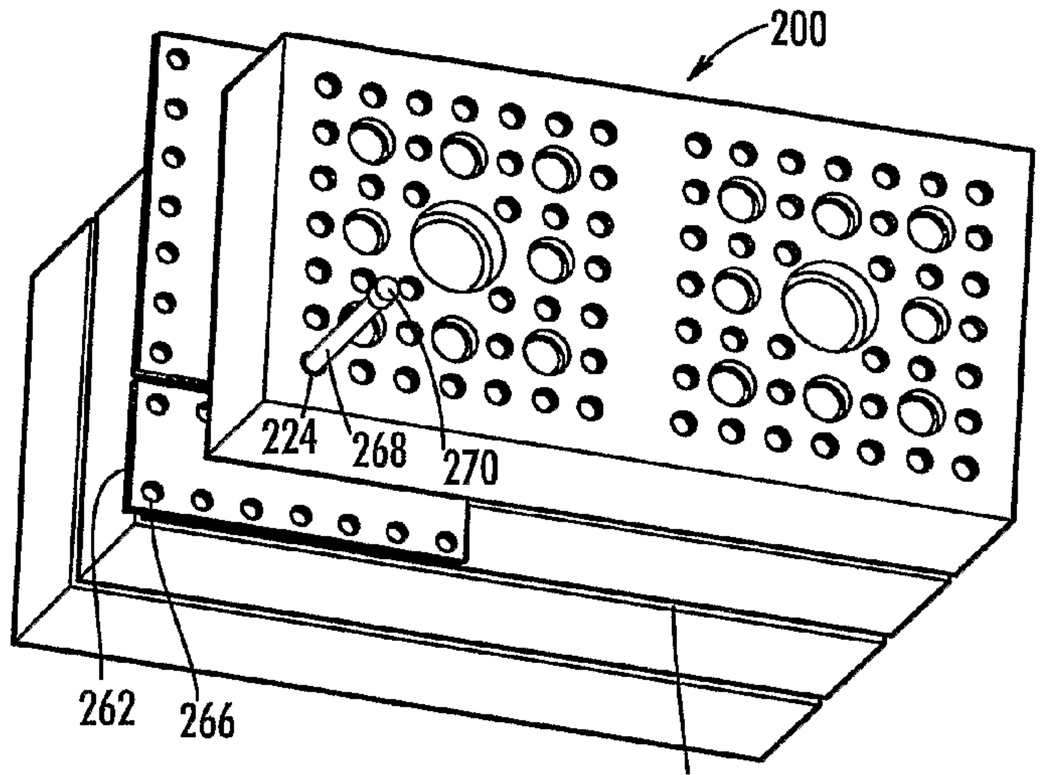

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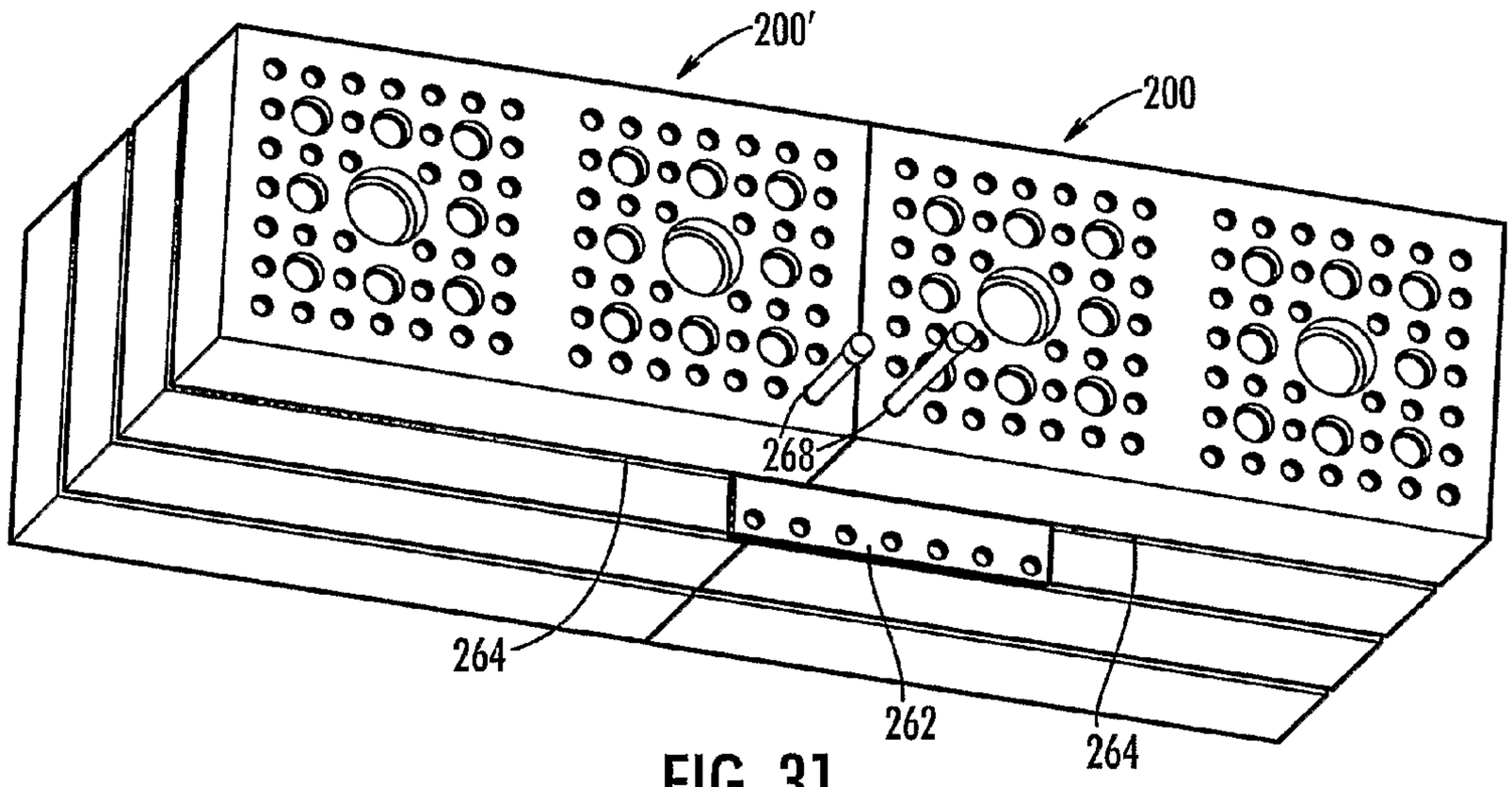

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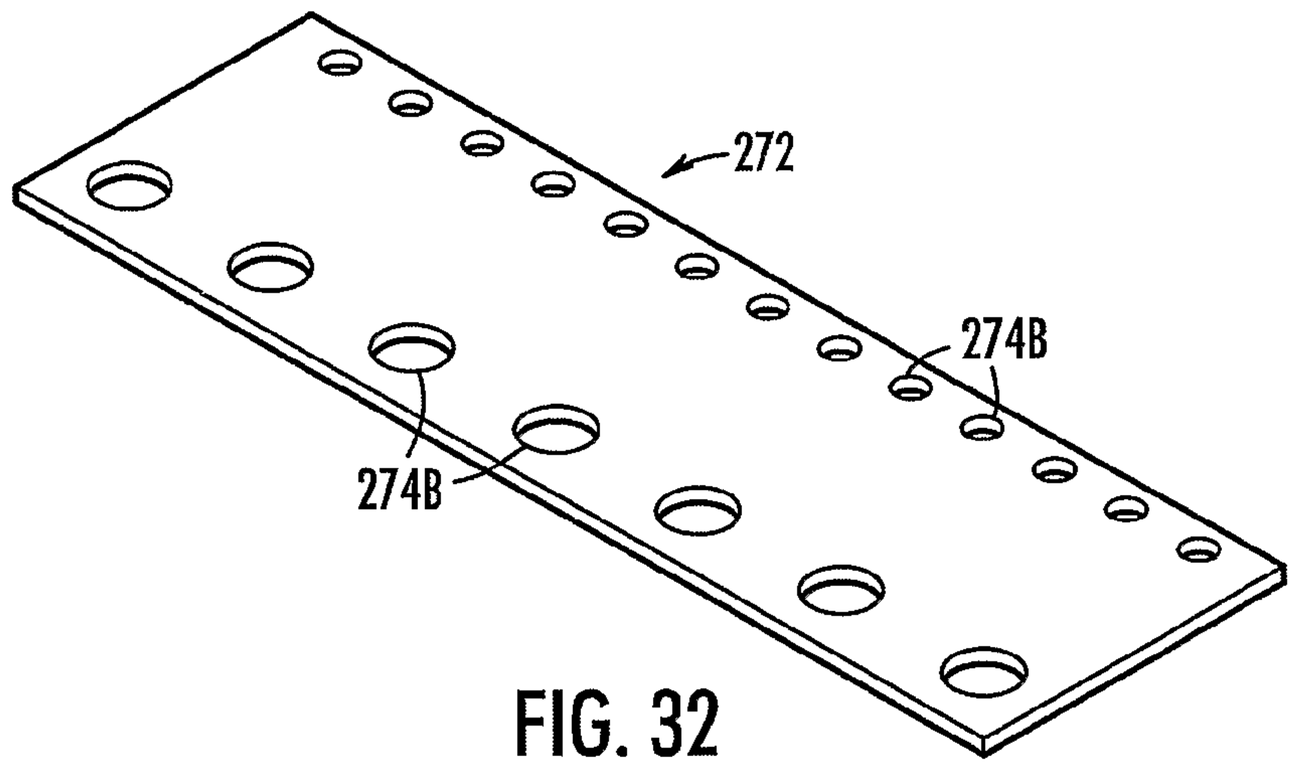

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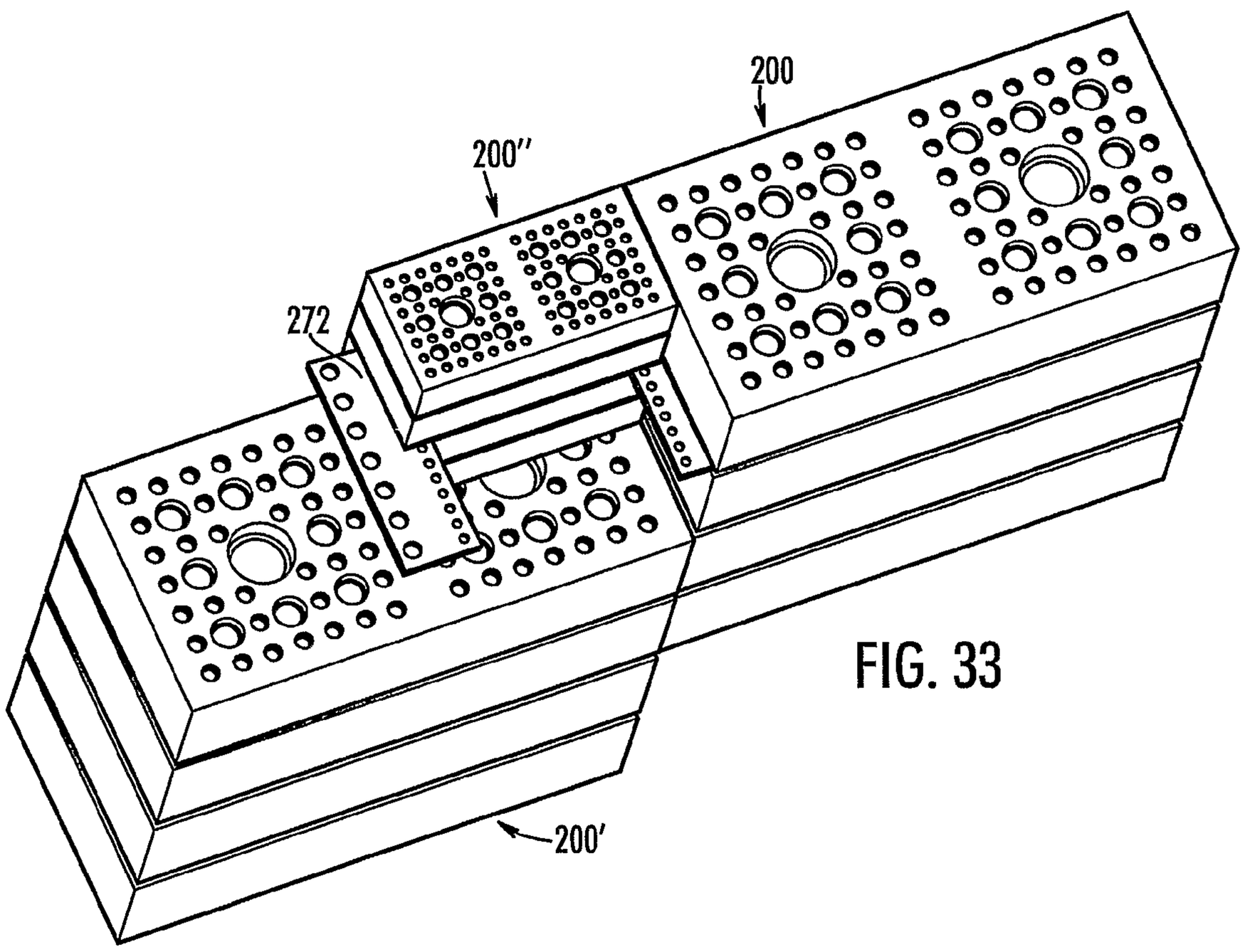


FIG. 33

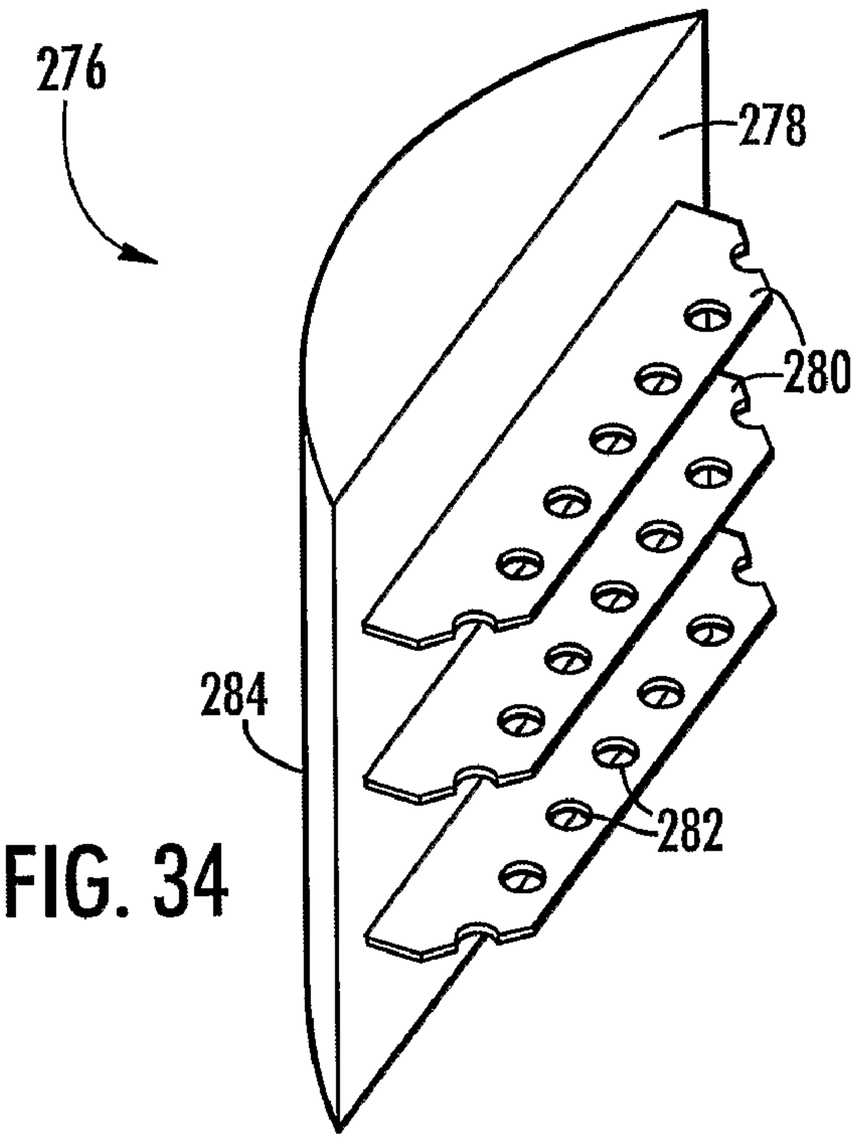
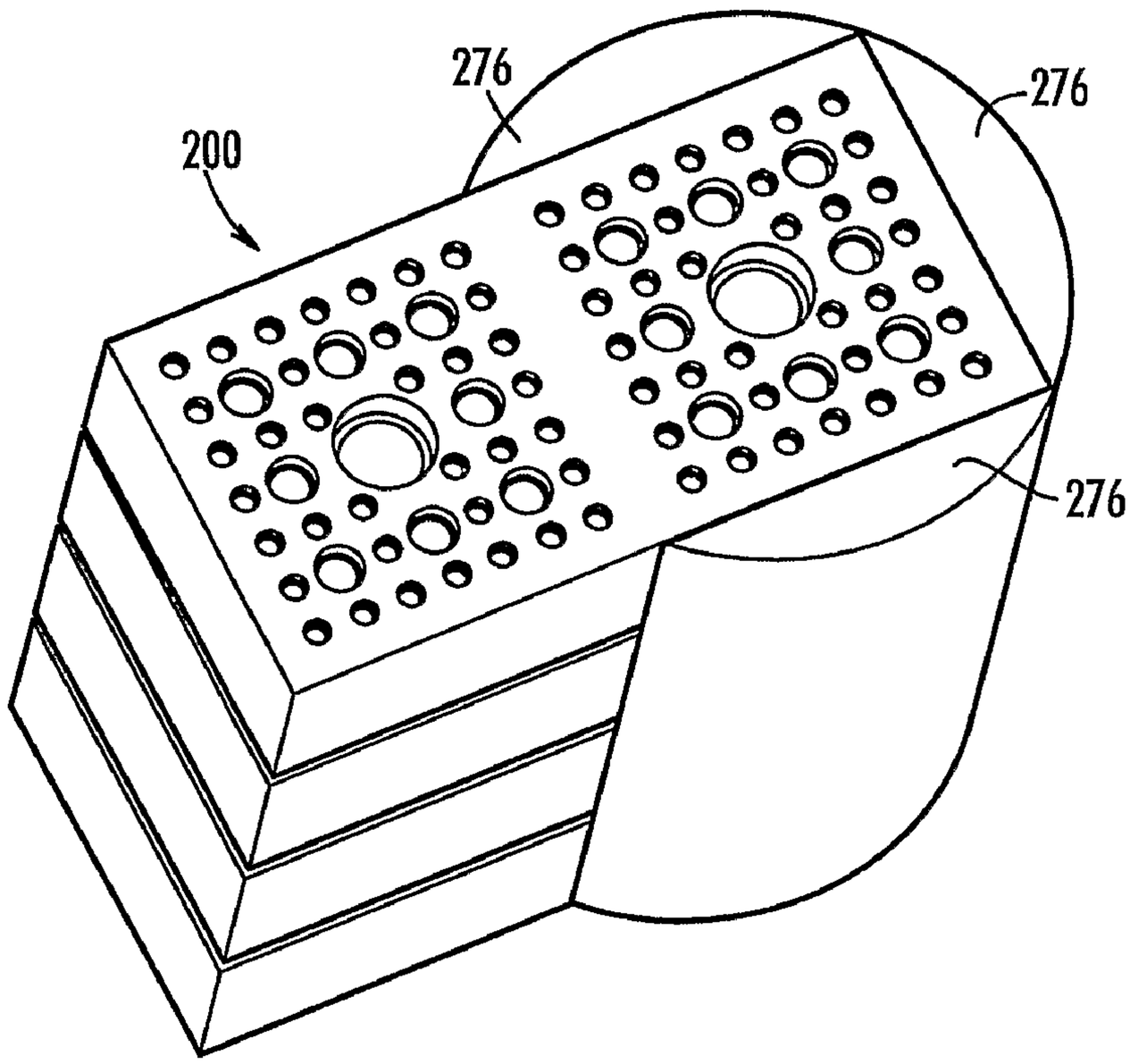


FIG. 34

FIG. 35



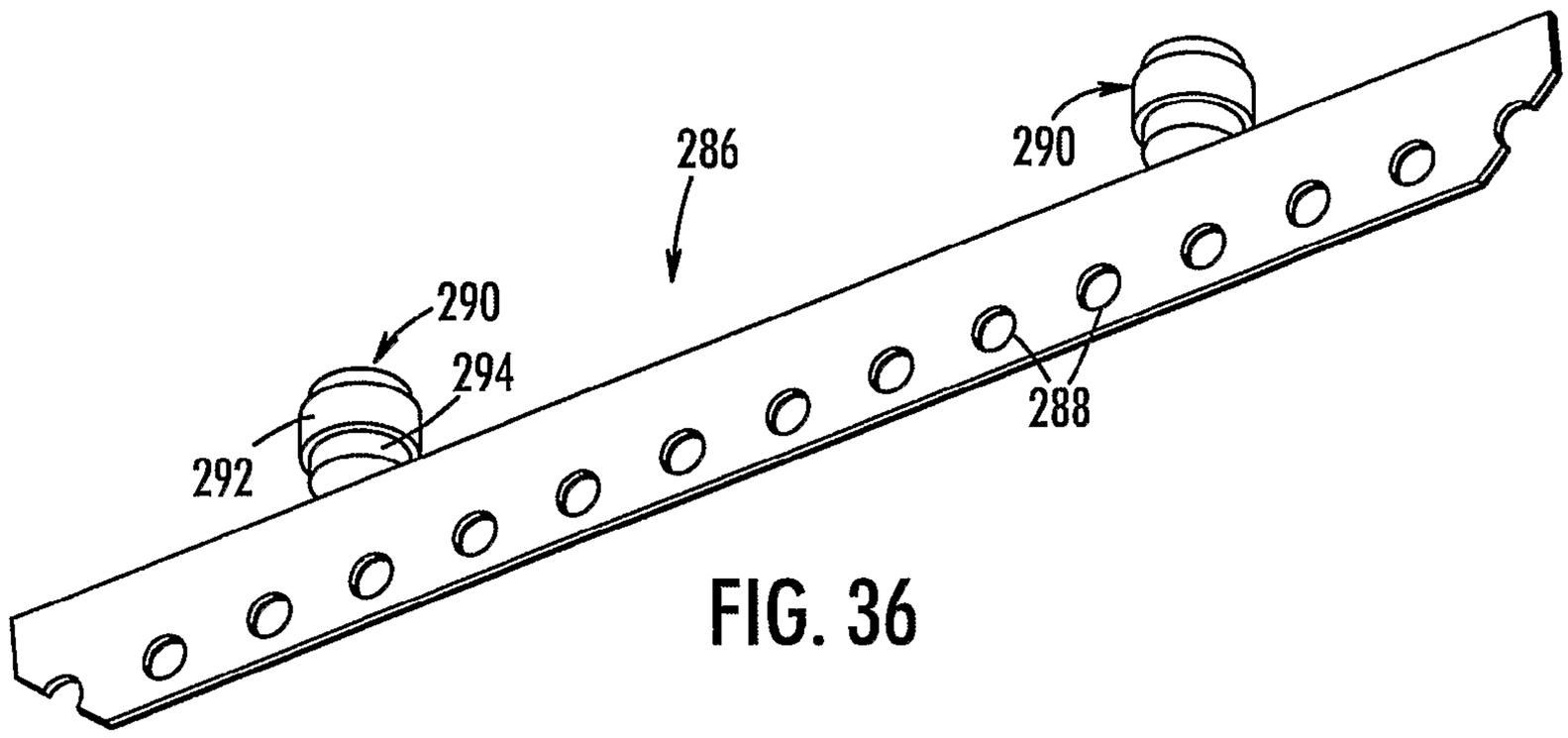


FIG. 36

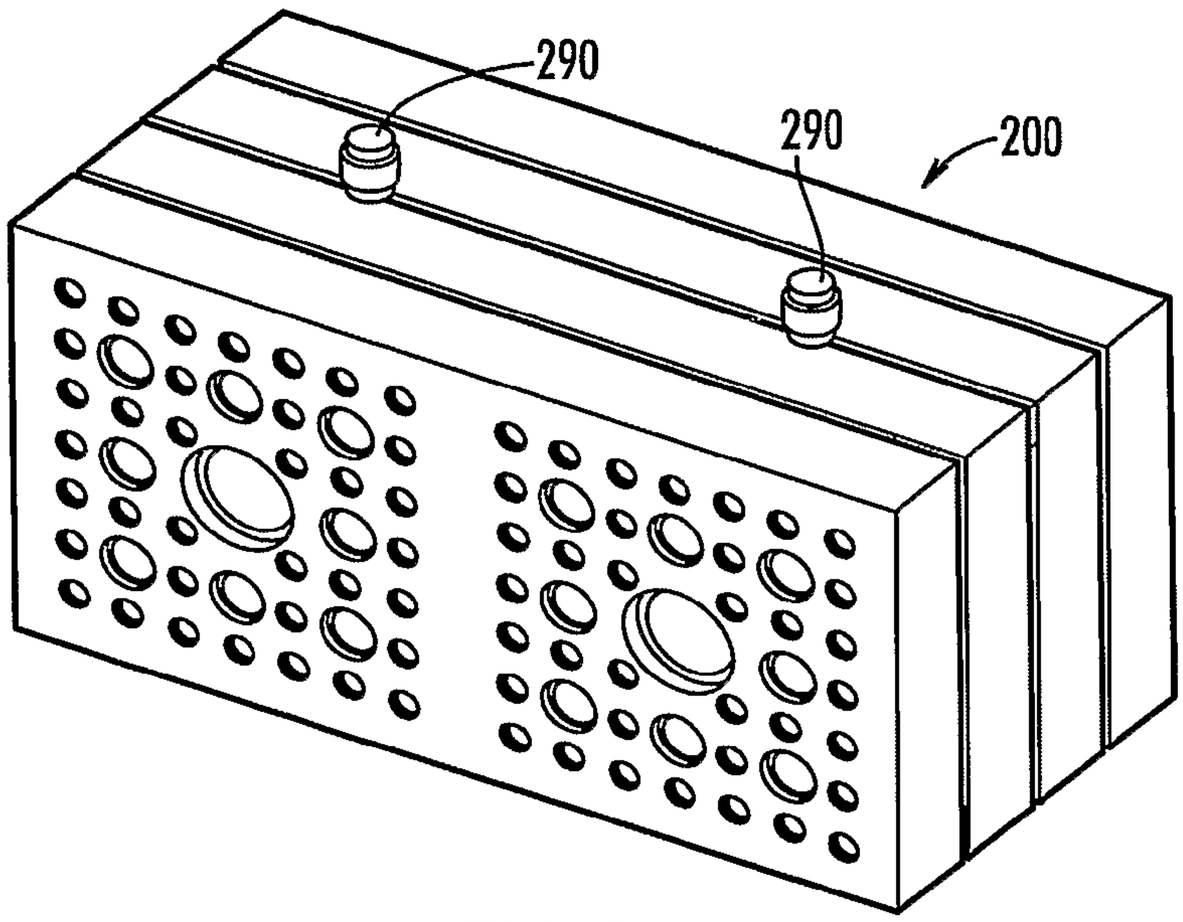


FIG. 37

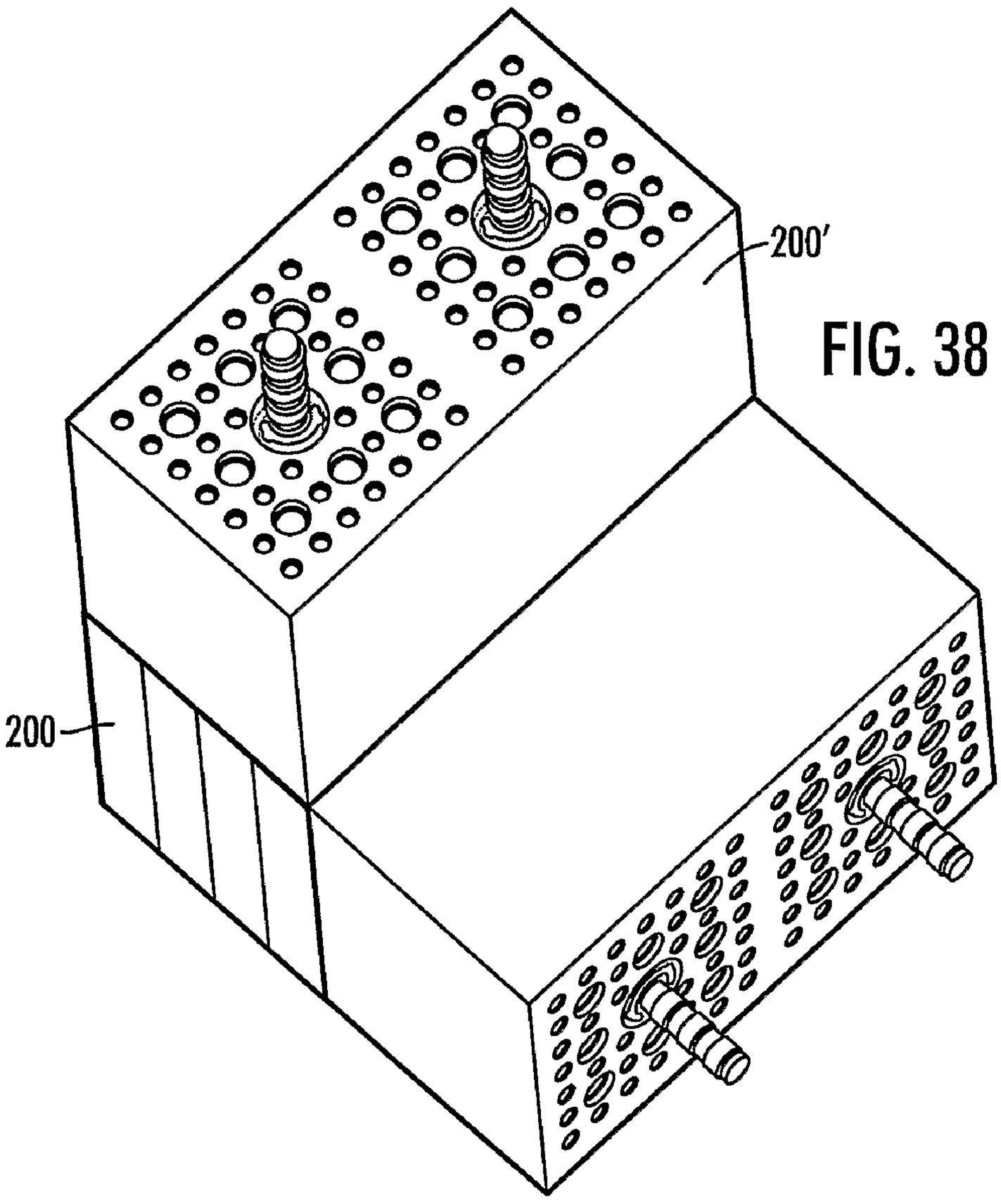


FIG. 38

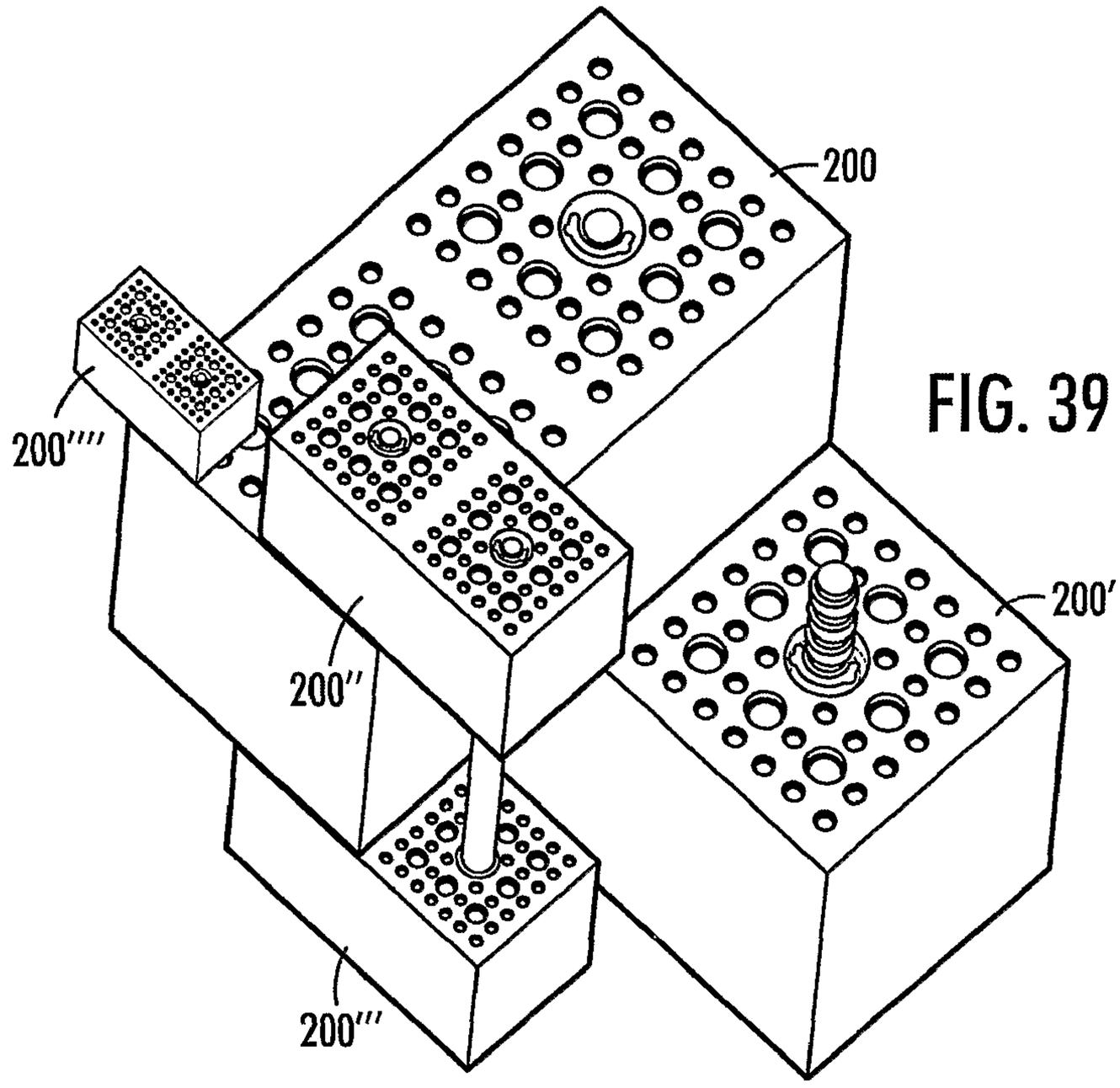


FIG. 39

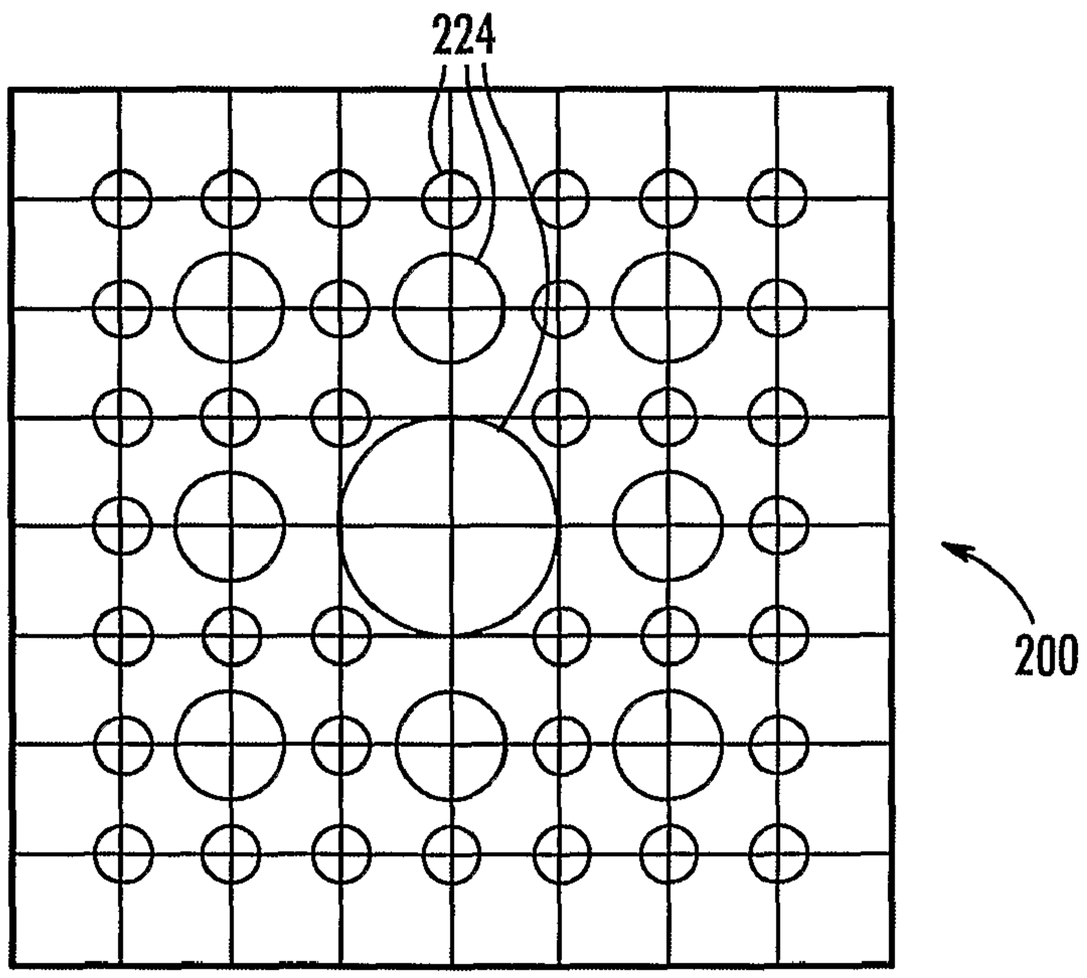


FIG. 43

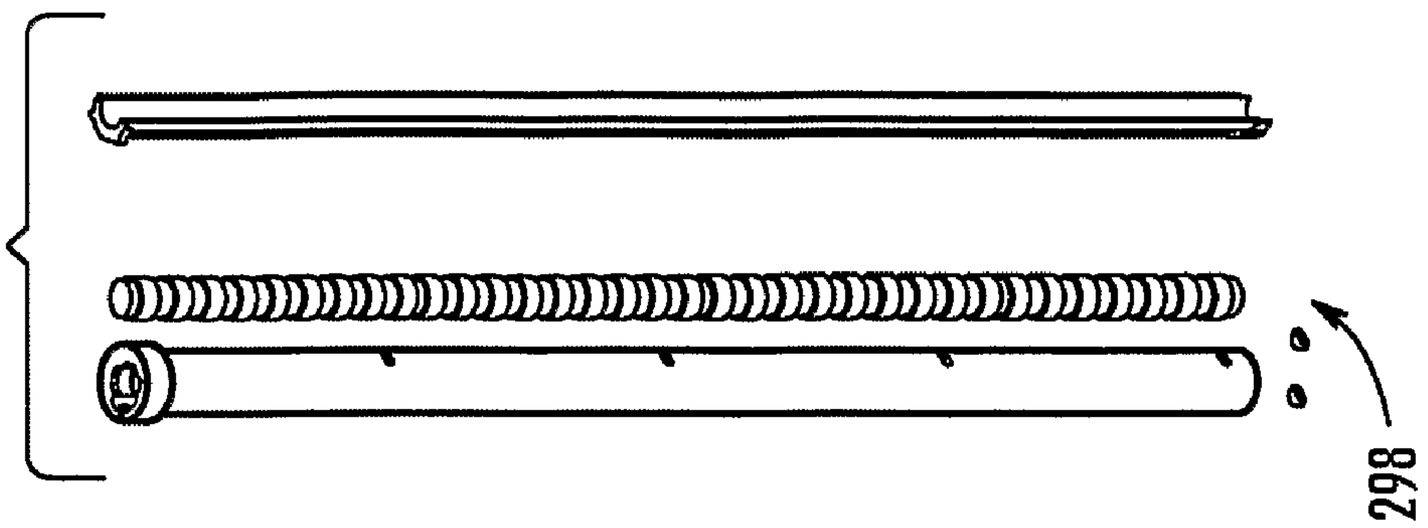


FIG. 42

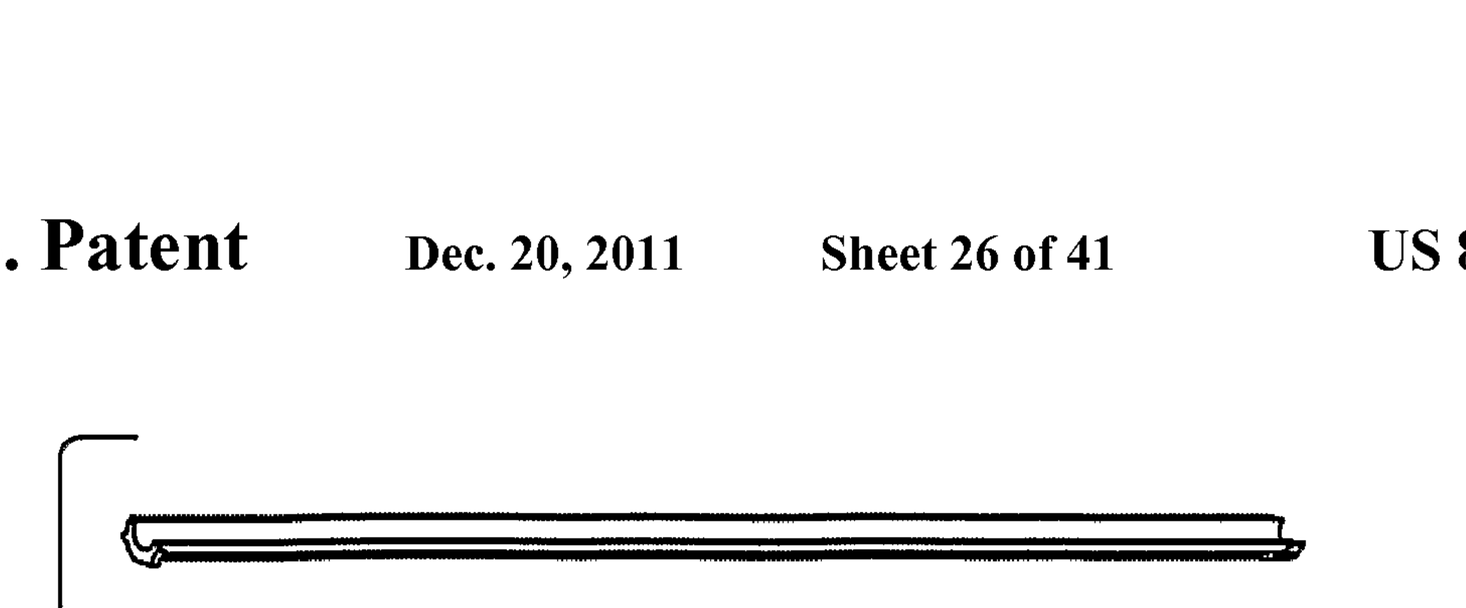


FIG. 41

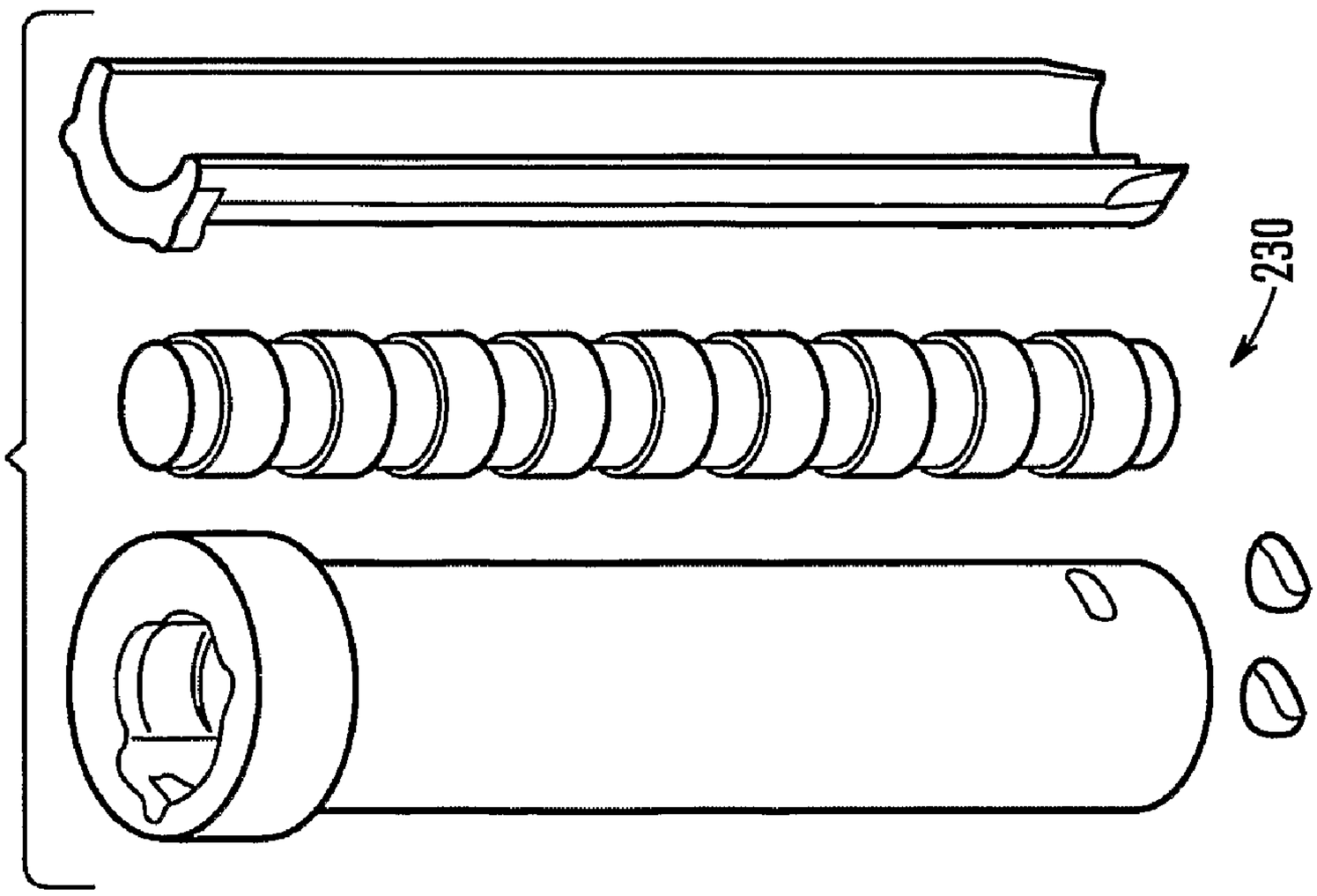


FIG. 40

FIG. 44

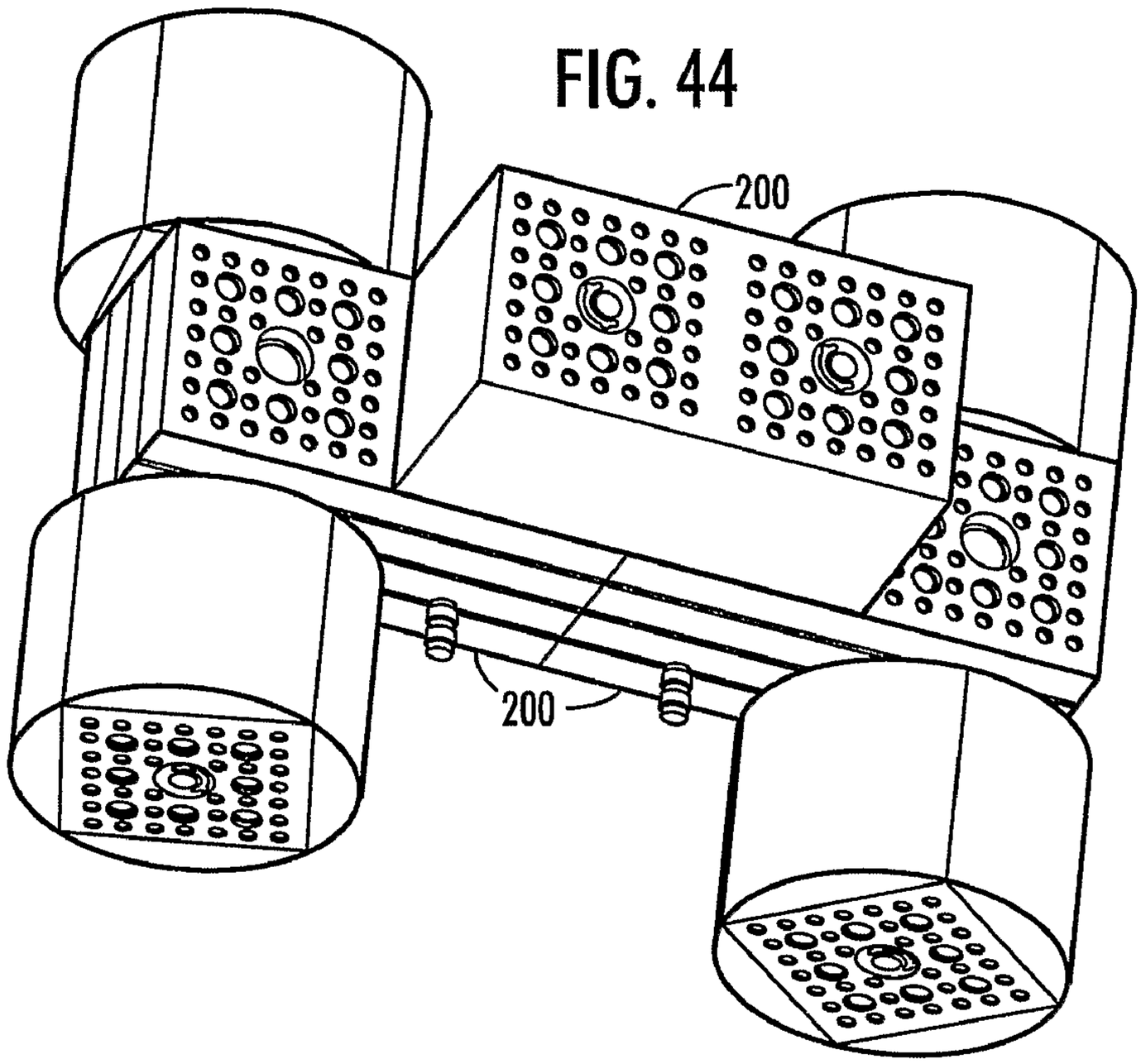
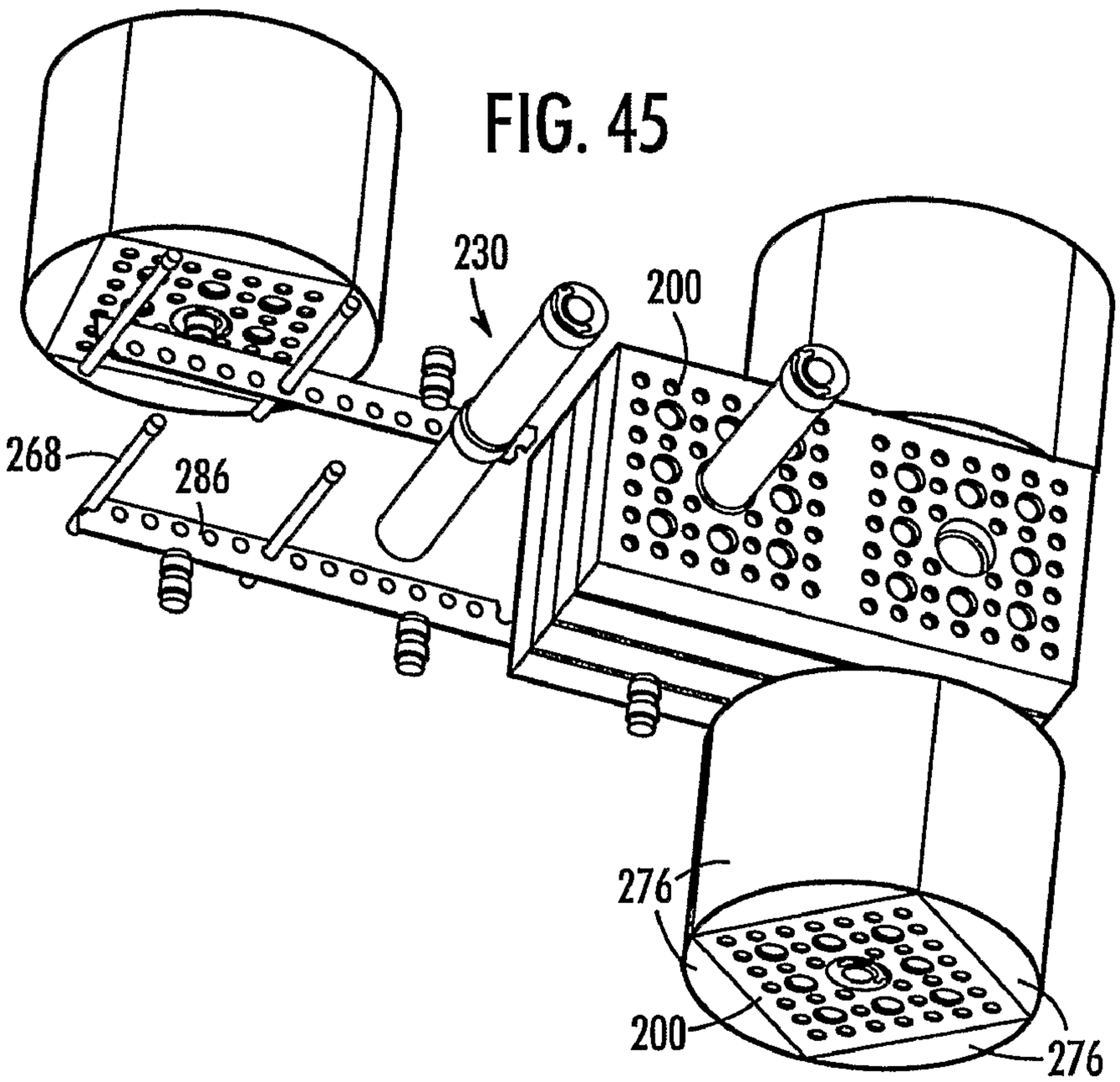


FIG. 45



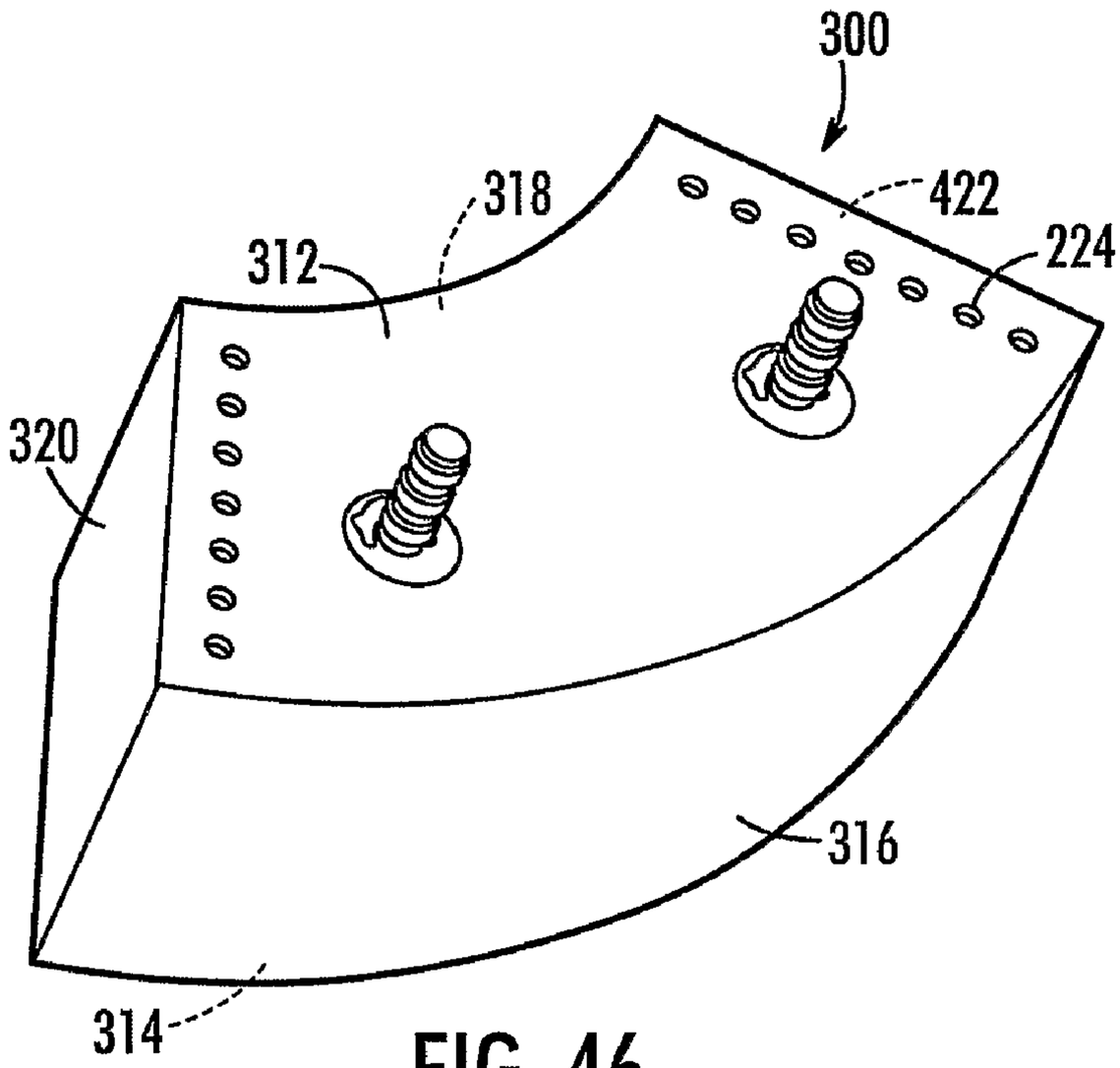


FIG. 46

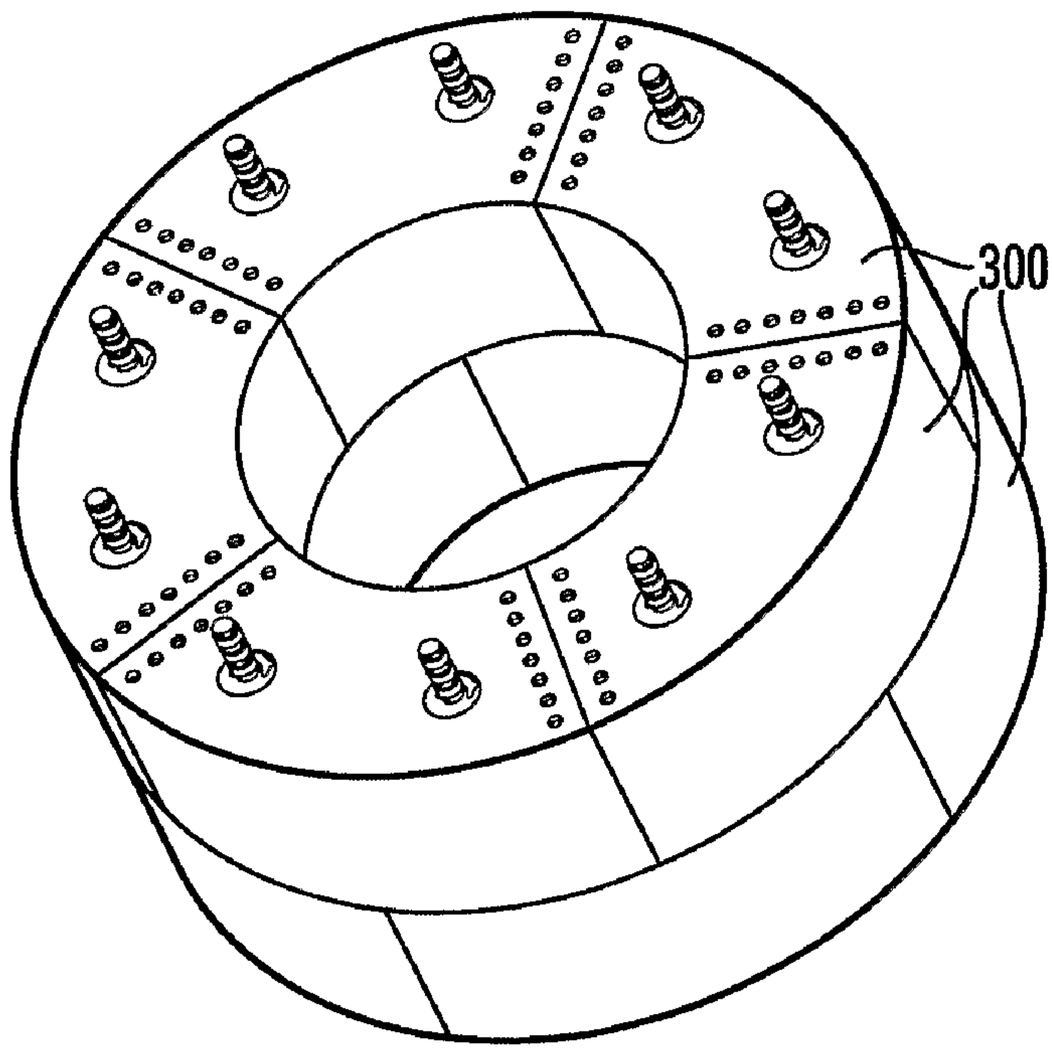


FIG. 47

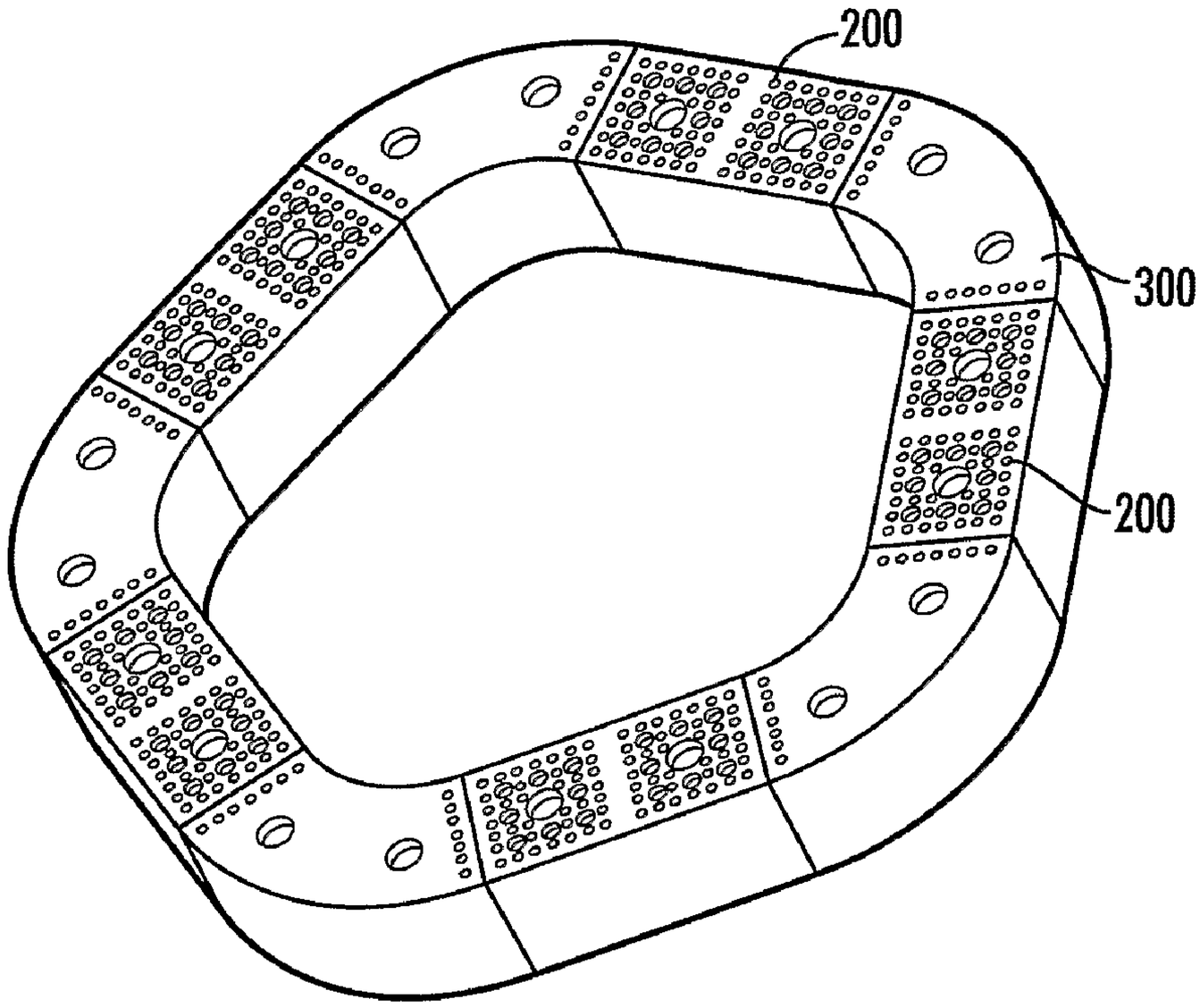


FIG. 48

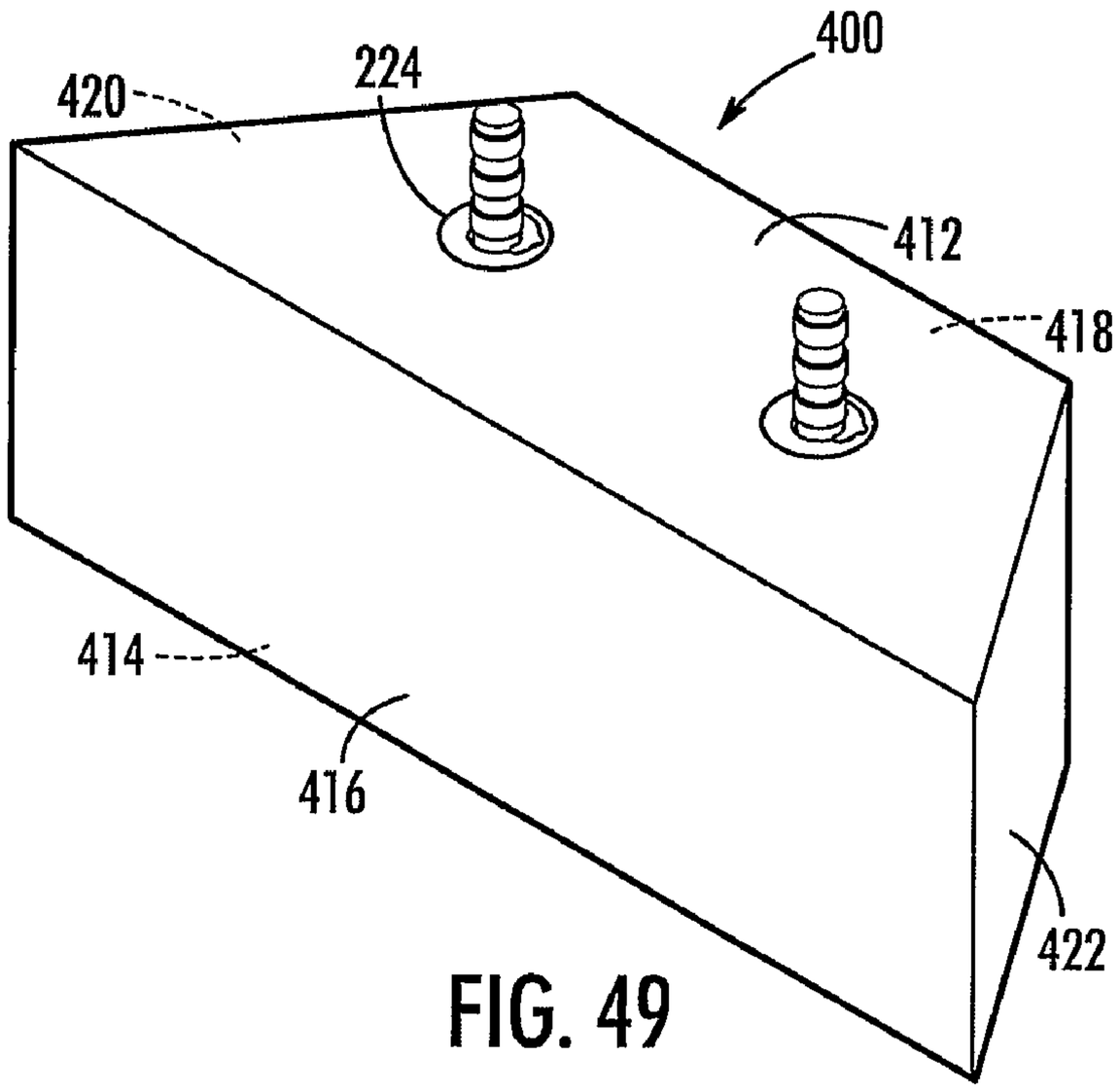


FIG. 49

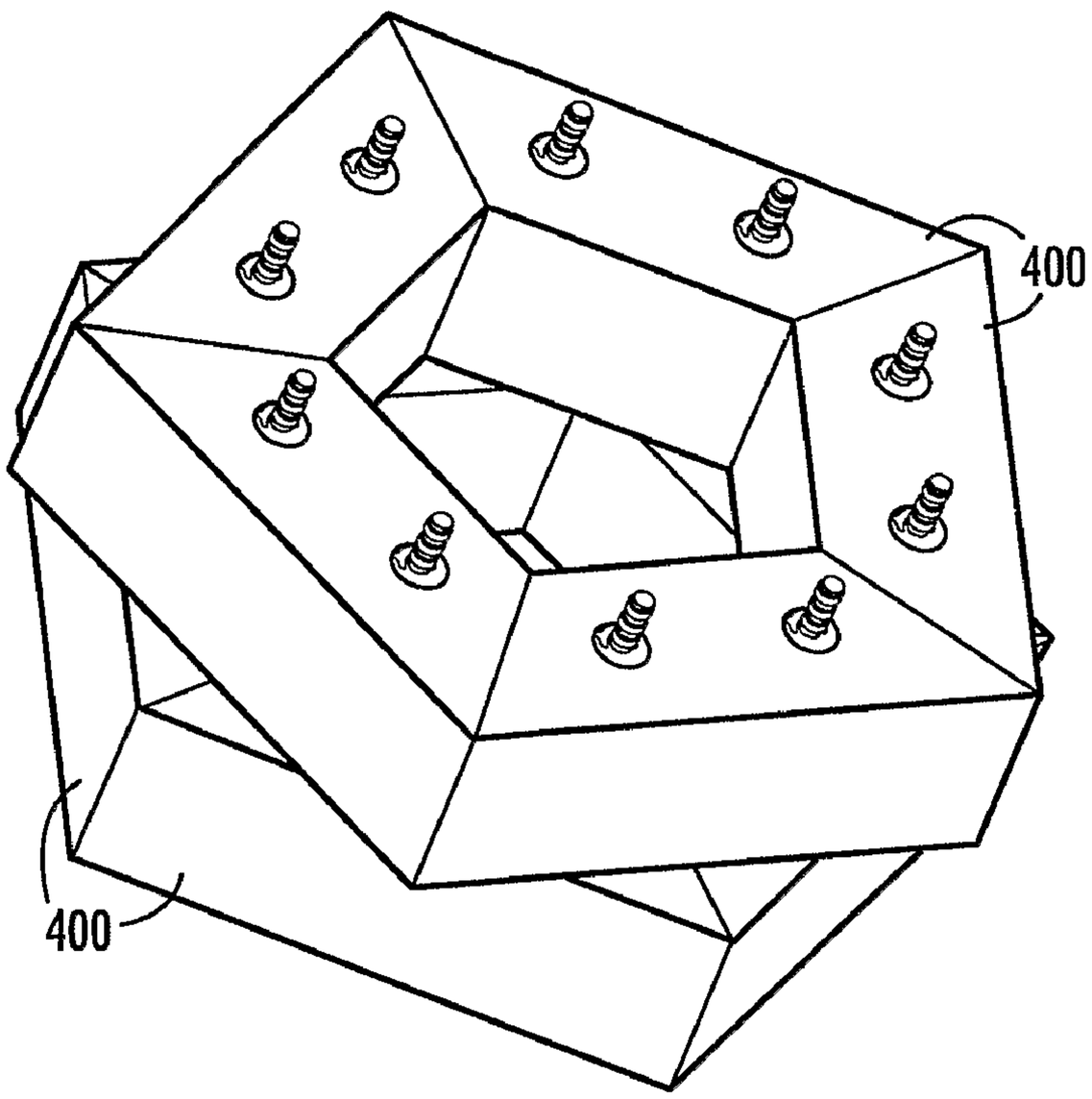


FIG. 50

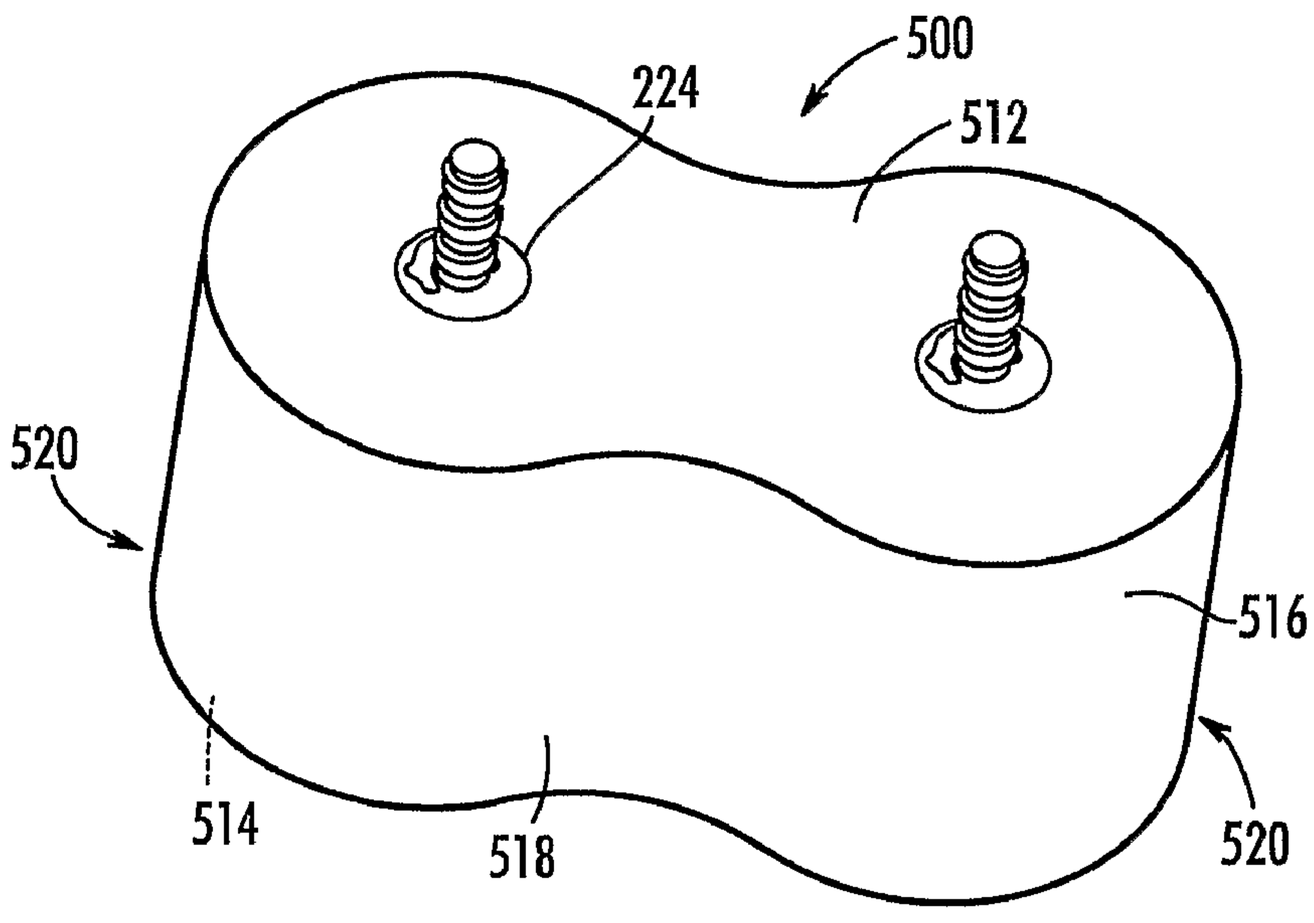


FIG. 51

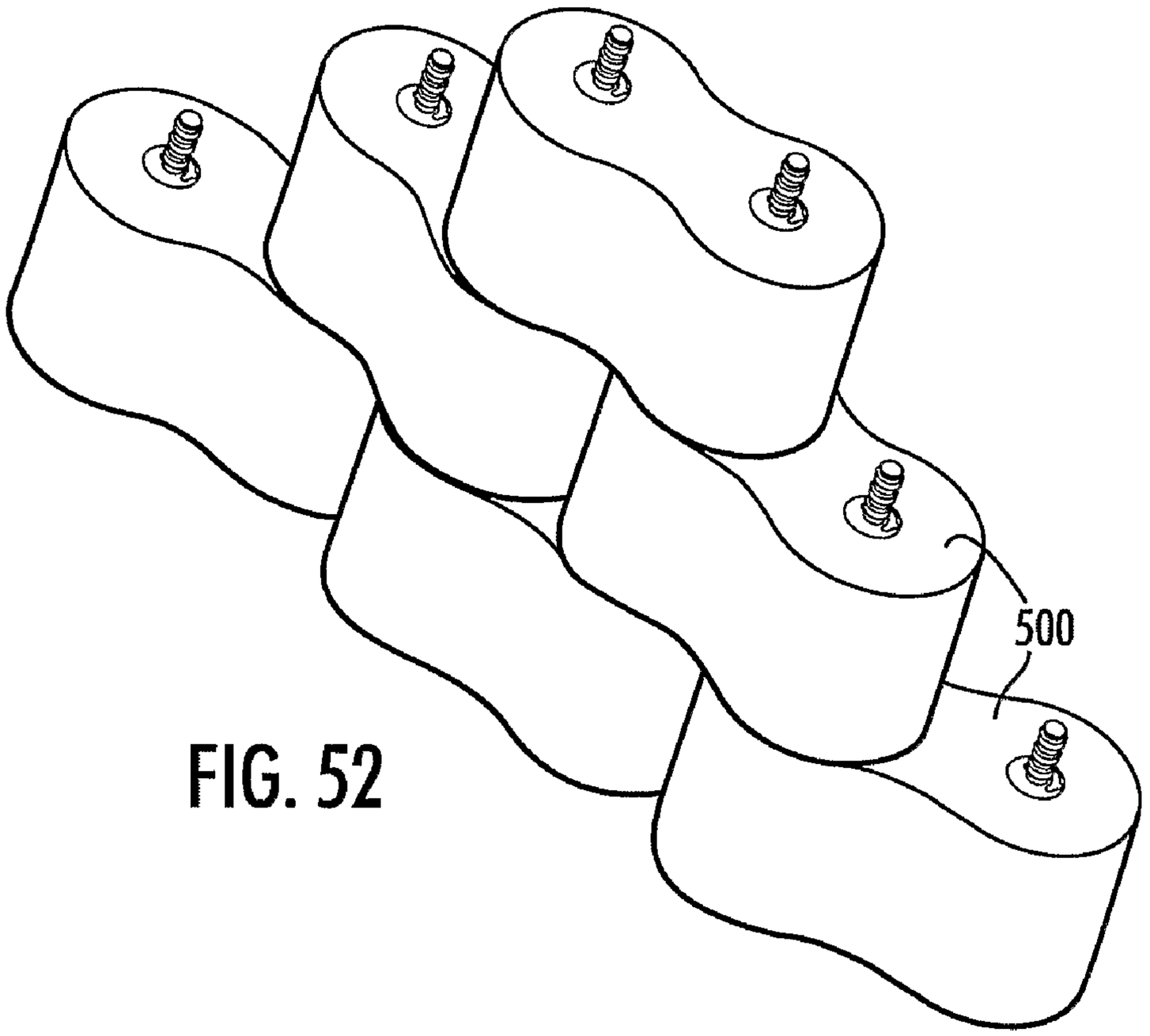


FIG. 52

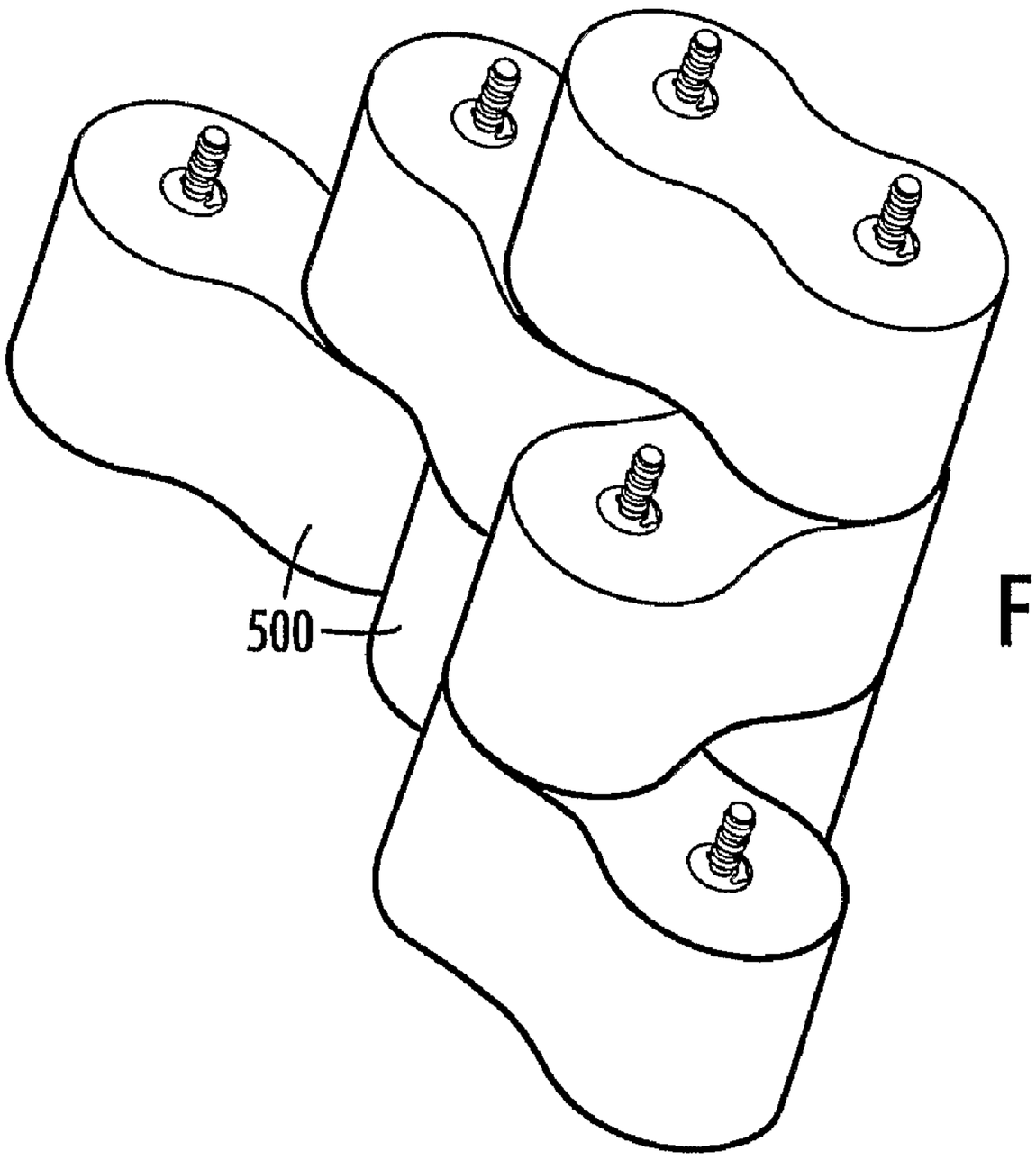


FIG. 53

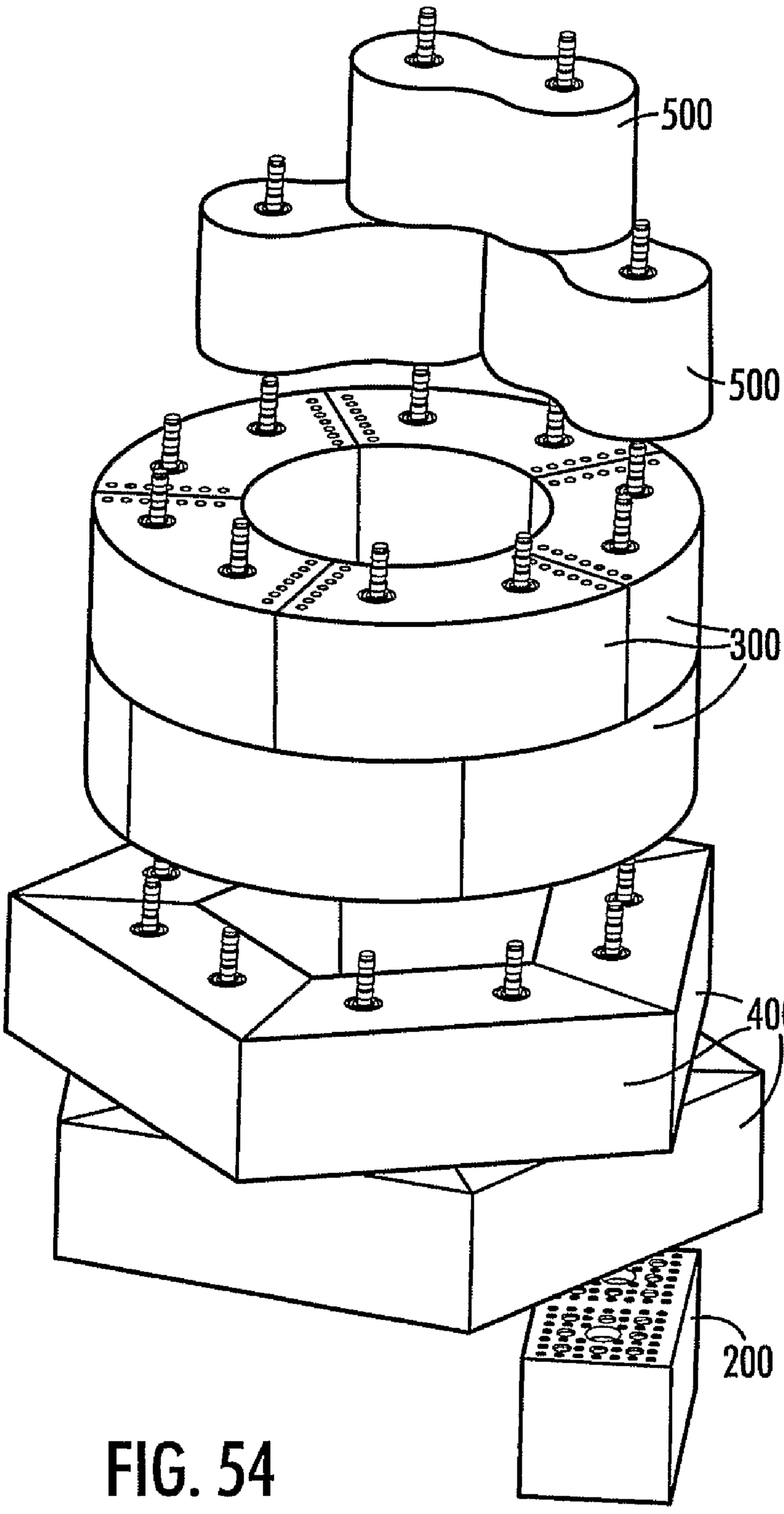


FIG. 54

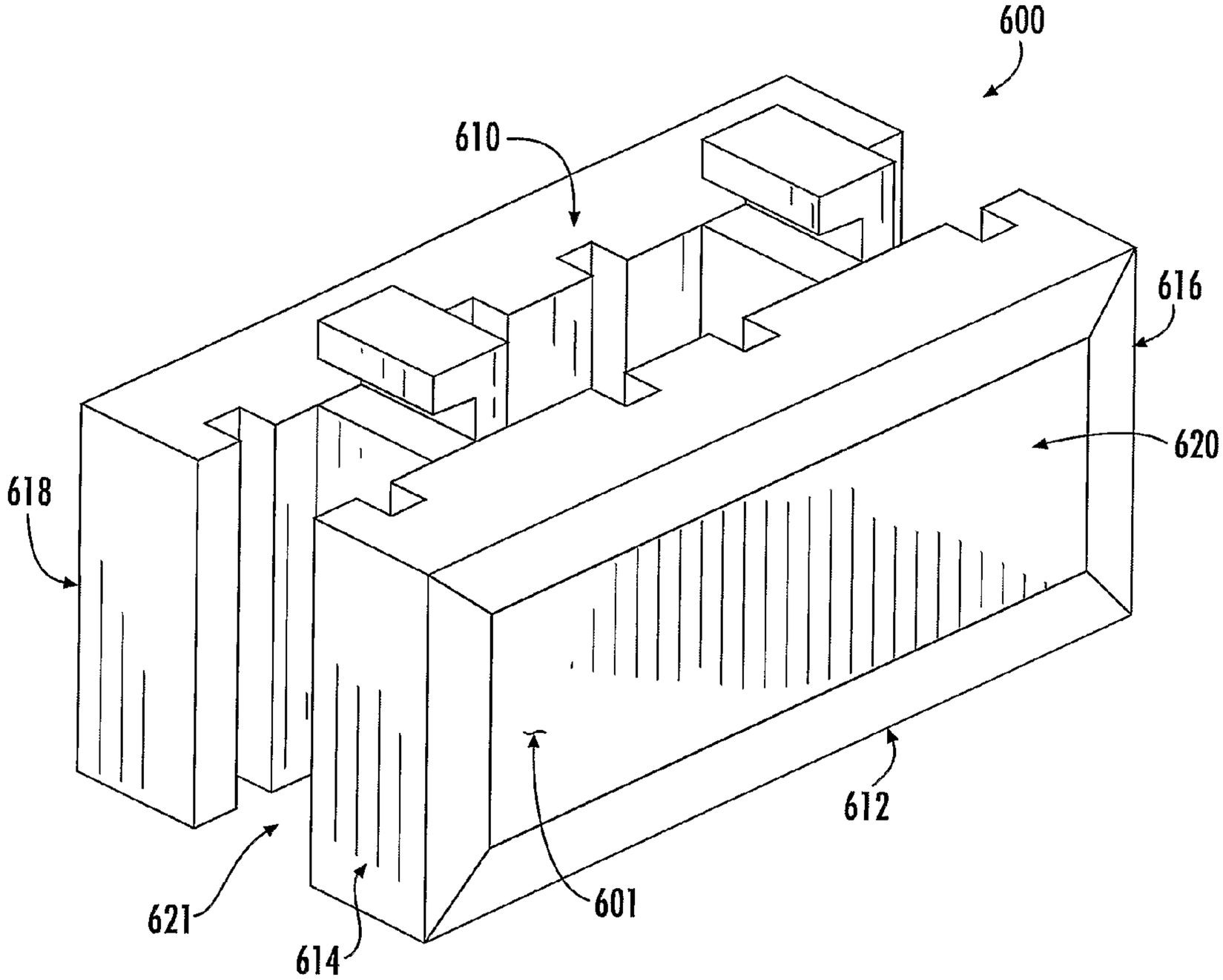


FIG. 55

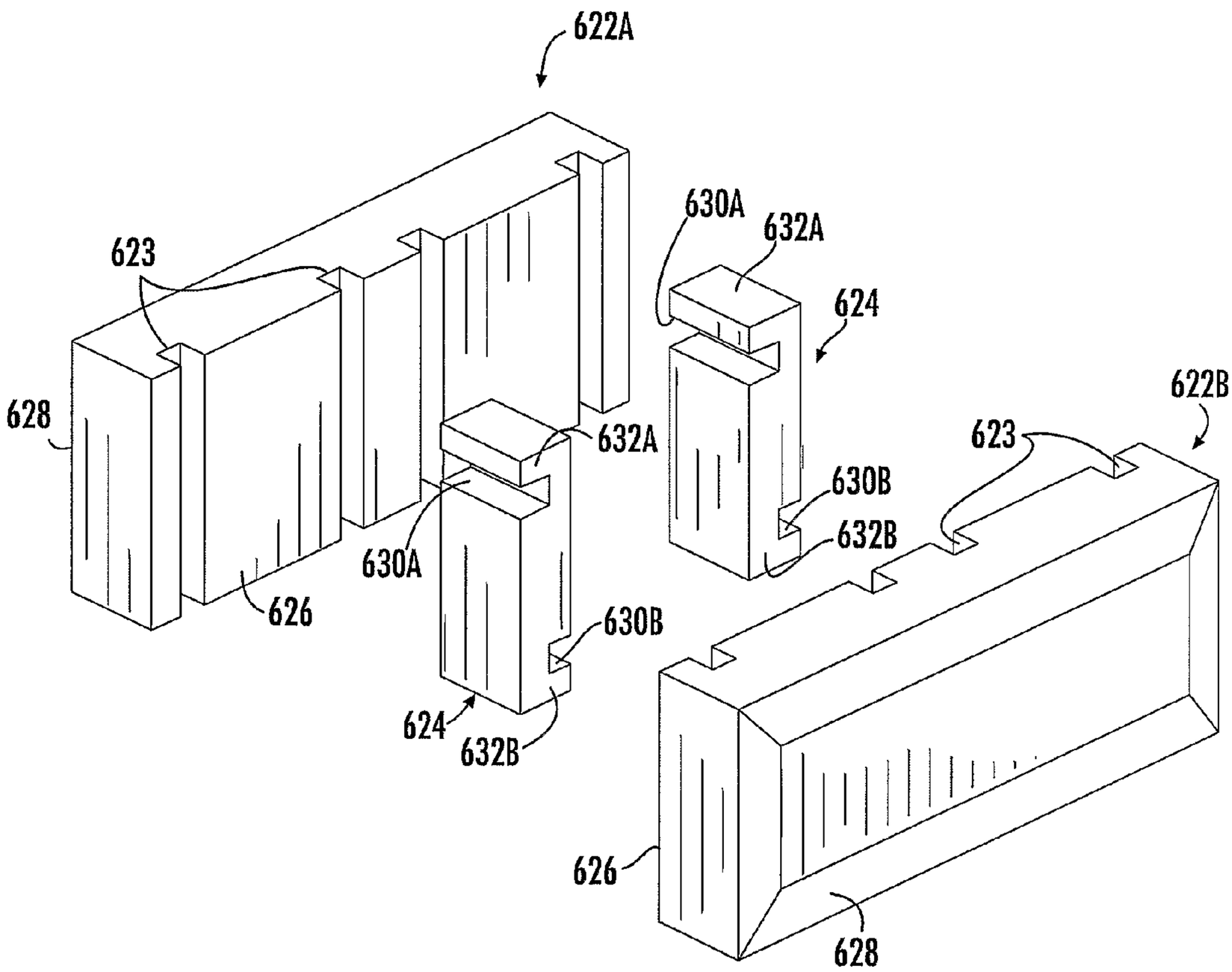

622A
623
628
626
630A
632A
624
632B
630B
630A
632A
624
630B
632B
622B
623
626
628

FIG. 56

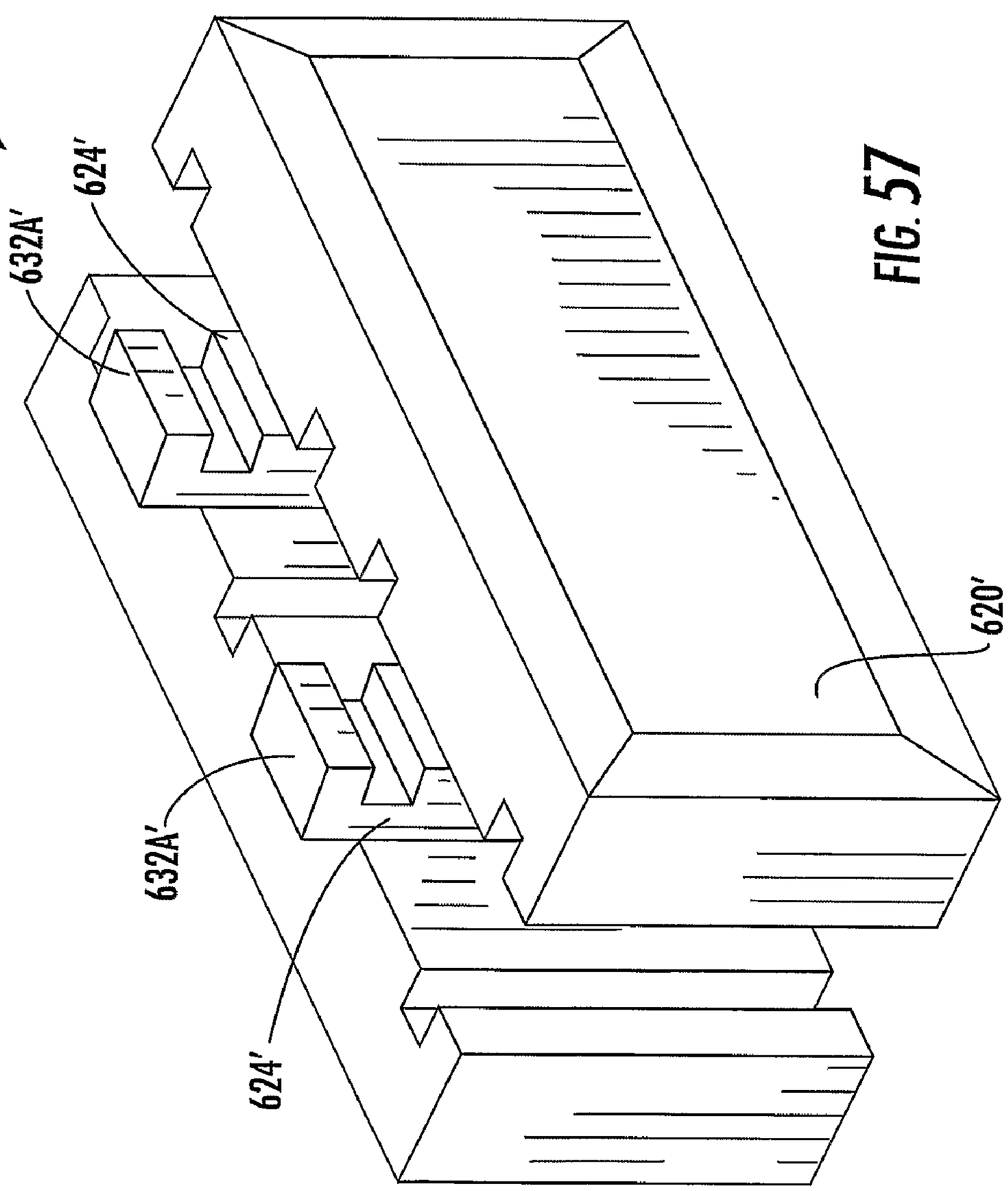


FIG. 57

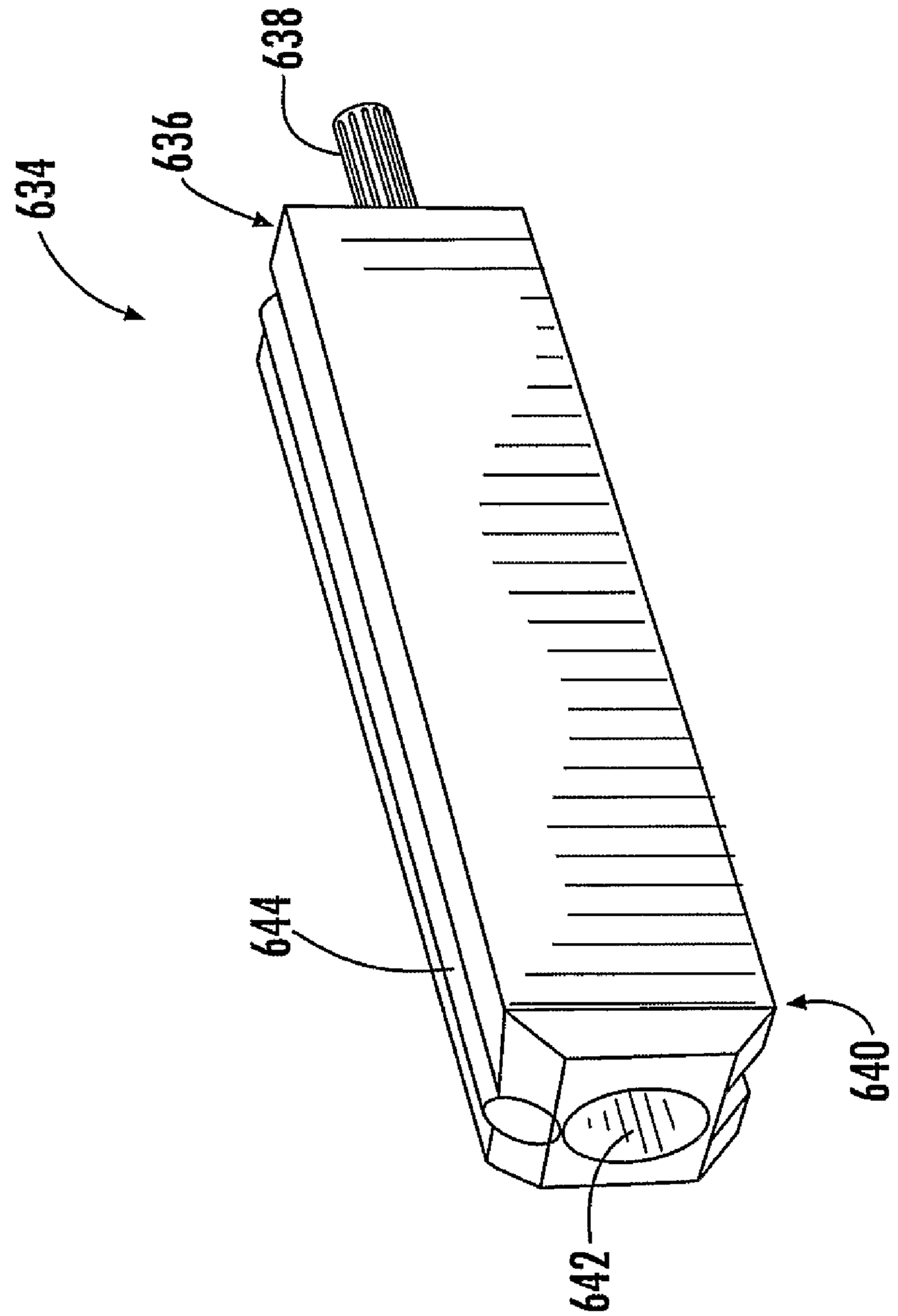


FIG. 58

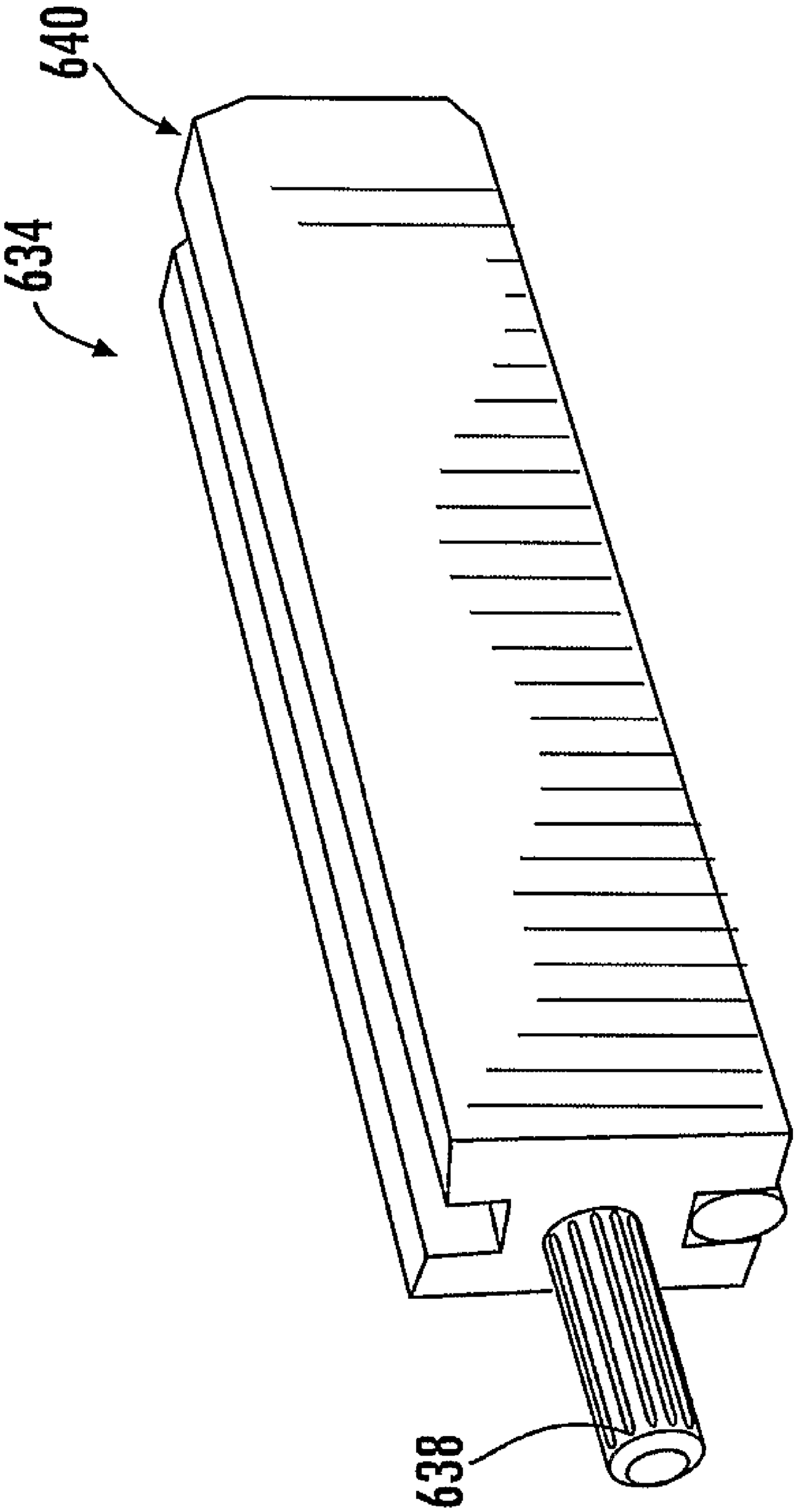


FIG. 59

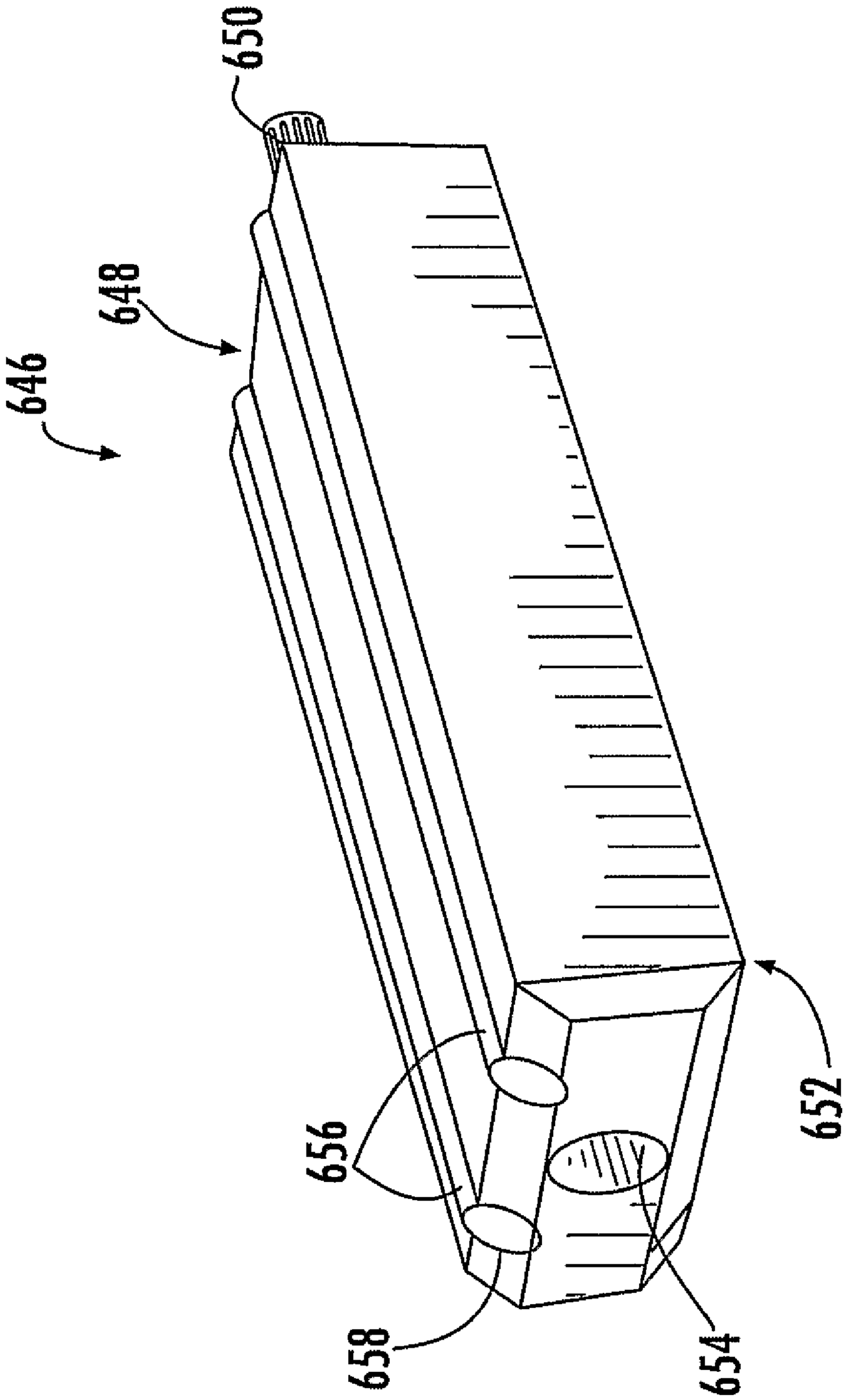


FIG. 60

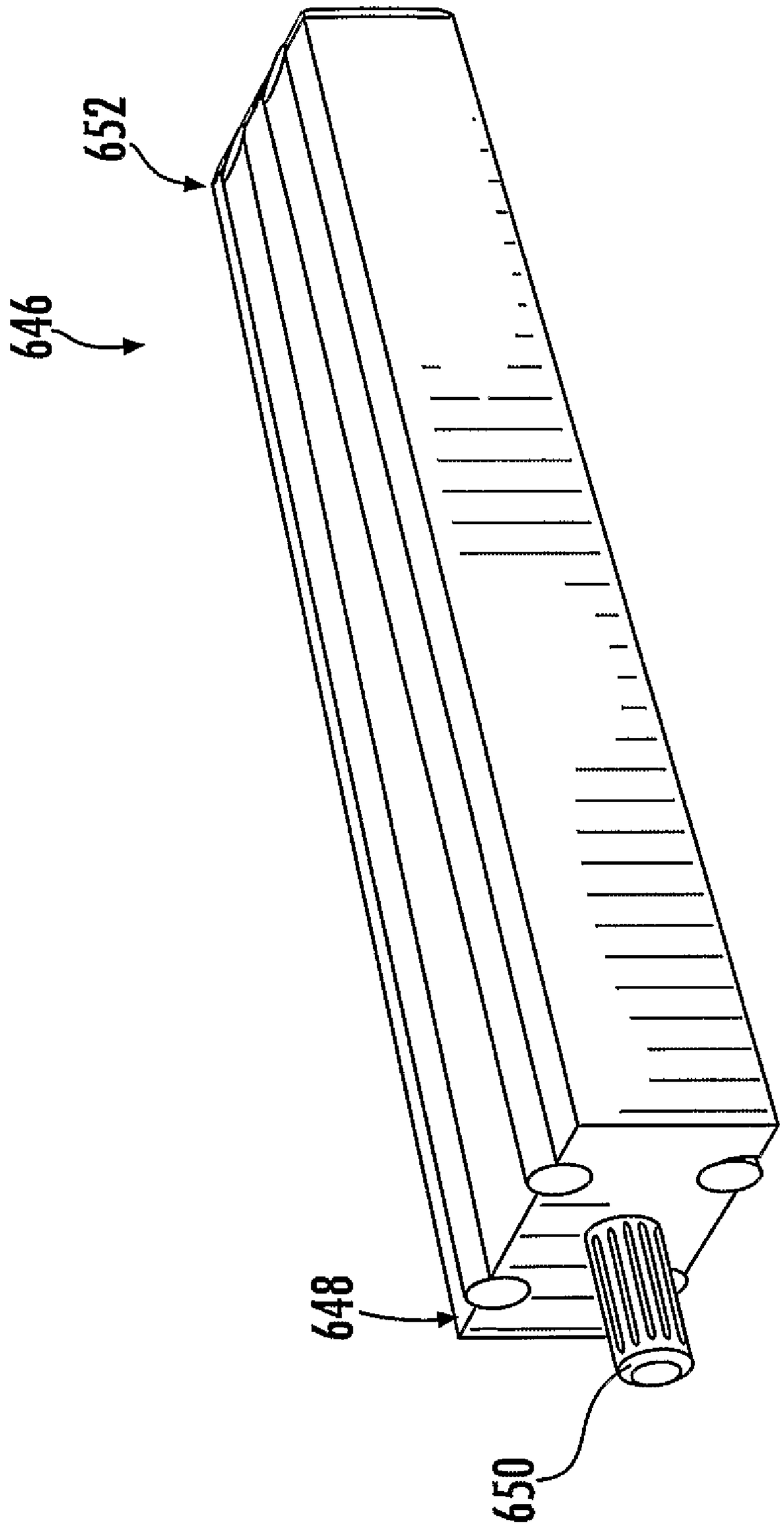


FIG. 61

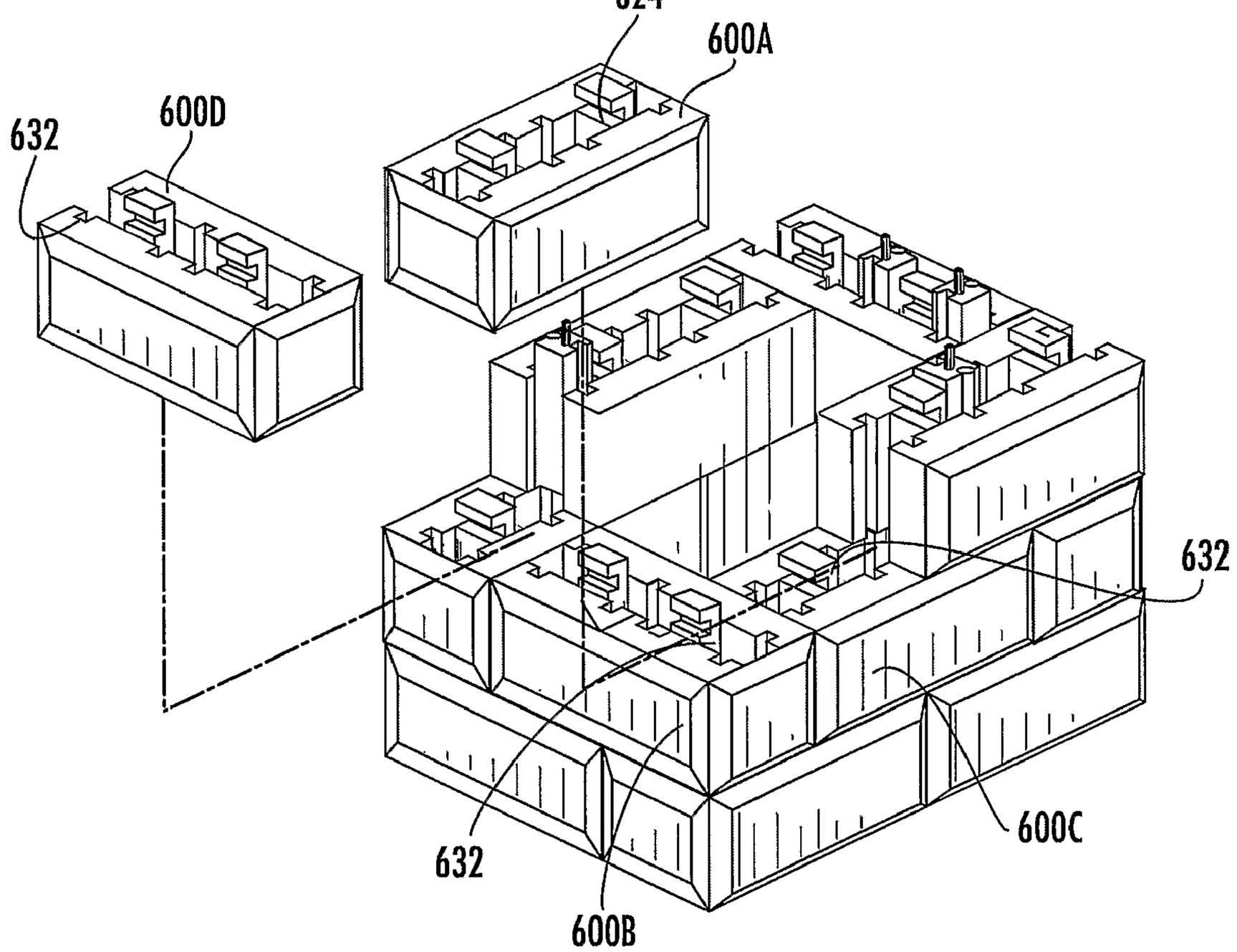


FIG. 62

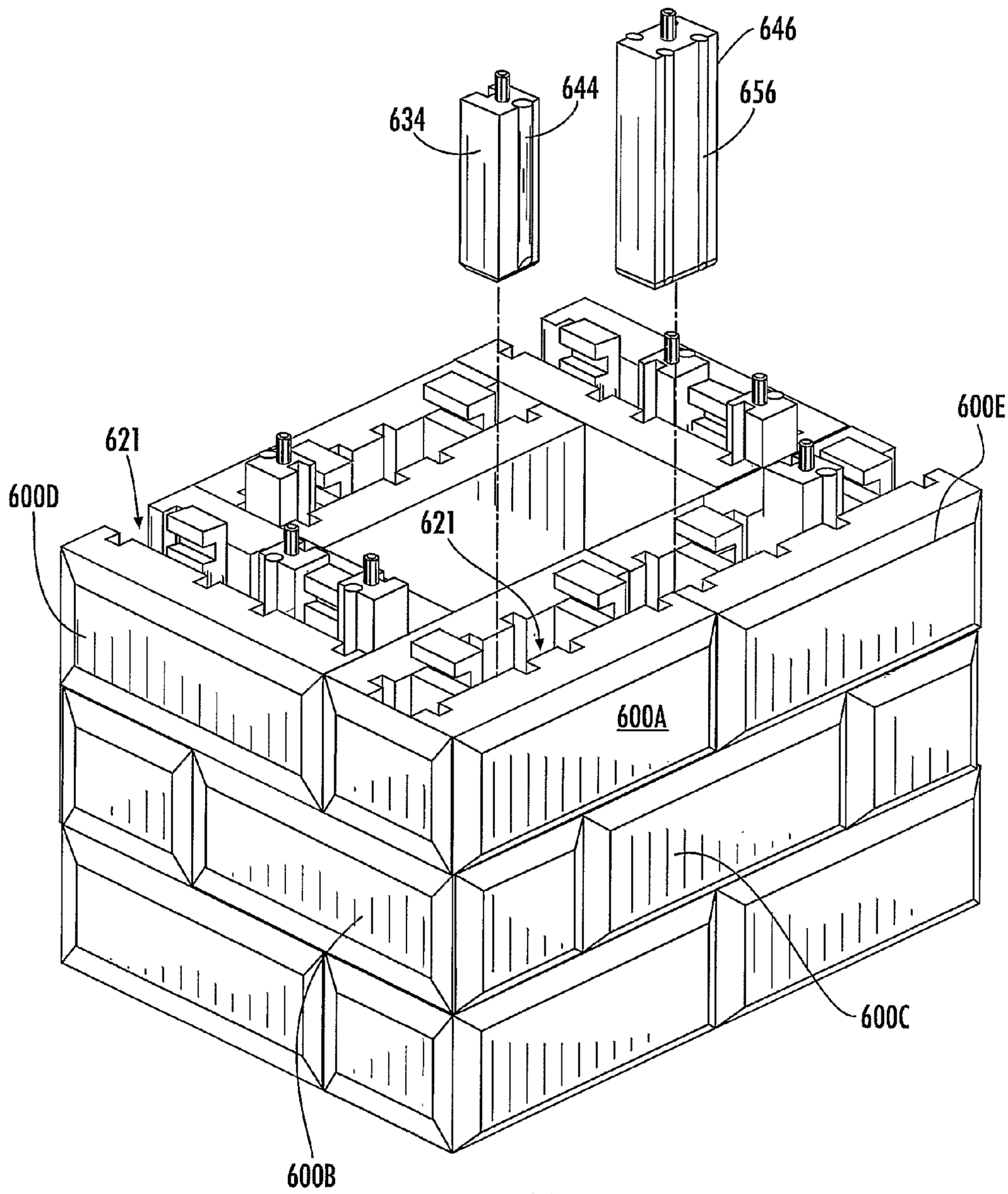


FIG. 63

MODULAR BLOCKS AND STRUCTURES MADE THEREFROM

BACKGROUND OF THE INVENTION

This invention relates generally to modular construction systems and more particularly to a system of modular blocks which can be connected in various ways.

Various construction systems exist in which identical or similar modular elements are built up into larger structures. Known examples of modular building elements include bricks and concrete blocks. While these provide a modular configuration, they lack a self-connecting feature and must be assembled with separate fasteners, adhesives, or mortar.

Systems of interlocking construction blocks are also known. These are typically used for toys or small-scale models, and typically rely on friction or snap-type connectors. While these systems provide a self-connecting feature, the user is limited to preformed blocks which have fixed connector elements.

Accordingly, there is a need for a modular construction element having a connector that can be configured in different ways.

BRIEF SUMMARY OF THE INVENTION

Therefore, it is an object of the invention to provide a block that can be used to build up modular structures.

It is another object of the invention to provide a modular block with a connector that can be oriented in different directions.

These and other objects are achieved by the present invention, which in one embodiment provides a modular block apparatus, including: first and second blocks, each block having a generally upwardly protruding locking member and an internal recess sized to receive the locking member of the other block such that the blocks can be assembled with one block above the other. The blocks are secured together in a vertical direction by relative lateral movement of the locking member and the internal recess. Means are provided for preventing relative lateral movement of the locking member and the internal recess so as to retain the blocks in a connected condition.

According to another embodiment of the invention, a modular block apparatus includes: a block with top and bottom surfaces, a front sidewall, and an interior cavity formed therein, the interior cavity defining a locking recess communicating with the bottom surface, and a lug receptacle communication with the top surface; and a locking lug received in the lug receptacle, the locking lug having a laterally-extending hook protruding above the top surface.

According to another embodiment of the invention, the lug receptacle includes at least one protruding side boss disposed therein; and the locking lug includes at least one lug boss disposed thereon. The lug bosses and the side bosses are arranged such that the hook faces in a selected one of a plurality of directions relative to the front sidewall, and the lug is retained, by engagement of the bosses, against withdrawal from the lug receptacle in a vertical direction.

According to another embodiment of the invention, the interior cavity includes a generally vertical portion extending between the lug receptacle and the locking recess.

According to another embodiment of the invention, the modular block apparatus further includes a key disposed in the vertical portion which prevents lateral motion of the locking lug.

According to another embodiment of the invention, the key prevents lateral motion of a hook received in the locking recess.

According to another embodiment of the invention, the block has at least one generally vertical edge, and includes: at least one open corner slot formed in the vertical edge; and a generally vertically-extending corner hole disposed near the vertical edges and intersecting the corner slot.

According to another embodiment of the invention, the modular block further includes: a connector plate having a thickness sized to fit in the corner slot, and a connector pin hole formed therethrough; and a connector pin sized to fit into the corner hole and the connector pin hole to retain the connector plate in the corner slot.

According to another embodiment of the invention, the connector plate further includes additional connector pin holes formed therethrough and is sized for engaging corner slots of at least two adjacent blocks.

According to another embodiment of the invention, the modular block apparatus further includes a finish element having: a exterior surface having a desired shape; and a laterally-extending connector plate having a thickness sized to fit in the corner slot, and a connector pin hole formed therethrough.

According to another embodiment of the invention, the hook is substantially smaller than the locking recess.

According to another embodiment of the invention, the block includes a plurality of laterally-extending hooks protruding above the top surface, and each of the hooks is substantially smaller than the locking recess.

According to another embodiment of the invention, the hook is substantially larger than the locking recess.

According to another embodiment of the invention, the block includes a plurality of laterally-extending hooks protruding above the top surface, and each of the hooks is substantially smaller than the locking recess.

According to another embodiment of the invention, a modular block apparatus includes: a block with top and bottom surfaces, and at least one generally cylindrical core passage extending between the top and bottom surfaces; and a locking assembly received in the core passage, the locking assembly including: a core sized to be received in the core passage and having a through-bore extending therethrough, the through-bore defining alternating core grooves and lands; a locking rod having an array of alternating rod grooves and lands complementary to the core grooves and lands; and means for retaining the locking rod in engagement with the core with the locking rod protruding from the top surface.

According to another embodiment of the invention, the retaining means comprise a rod key received in the through-bore and urges the locking rod laterally against the core grooves and lands.

According to another embodiment of the invention, the core passage includes at least one key slot extending laterally therefrom, the key slot being in communication with the bottom surface; and the core carries at least one core key which is moveable between a retracted position and a laterally-extended position. Engagement of the locking means causes the core key to move to the laterally-extended position, where the core key engages the core key slot to prevent withdrawal of the core assembly from the core passage.

According to another embodiment of the invention, the modular block apparatus further includes: a connector plate having a thickness sized to fit in the connector slot, and a connector pin hole formed therethrough; and a connector pin sized to fit into the core passage and the connector pin hole to retain the connector plate in the connector slot.

According to another embodiment of the invention, the connector plate has a generally cylindrical stud protruding therefrom, the stud including a land sized and shaped to engage the core grooves and lands.

According to another embodiment of the invention, the block includes a plurality of core passages of different diameters formed therein.

According to another embodiment of the invention, the block is a generally rectangular solid.

According to another embodiment of the invention, the block is curved.

According to another embodiment of the invention, the block is trapezoidal.

According to another embodiment of the invention, the block includes a pair of lobes connected by a relatively narrow waist.

According to another embodiment of the invention, a modular block apparatus includes: a block with top and bottom surfaces, a front sidewall, and an interior space formed therein. The block includes; first and second spaced-apart side members each having an inner surface and an outer surface; and at least one locking lug disposed between the side members, the locking lug having upper and lower notches formed near each its upper and lower ends, respectively, so as to define upper and lower laterally-extending hooks, wherein the upper hook protrudes from the top surface, and is sized and shaped to engage a lower notch of a second block.

According to another embodiment of the invention, the hook extends towards the front sidewall.

According to another embodiment of the invention, the hook extends generally perpendicular to the front sidewall.

According to another embodiment of the invention, the side members and the locking lug are a single integral component.

According to another embodiment of the invention, the modular block apparatus further includes at least one generally vertical key groove formed in the side members.

According to another embodiment of the invention, the modular block apparatus further includes a key received in the interior space and having an alignment rail which engages the key groove, the key extending between upper and lower positioned blocks to prevent relative lateral movement thereof.

According to another embodiment of the invention, the key includes at least two spaced-apart alignment rails which are adapted to engage respectively key grooves of two laterally-adjacent blocks to prevent separation thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be best understood by reference to the following description taken in conjunction with the accompanying drawing figures in which:

FIG. **1** is a perspective view of a modular block constructed in accordance with the present invention;

FIG. **2** is a another perspective view of the modular block of FIG. **1**;

FIG. **3**A is a perspective view of a pair of modular blocks constructed in accordance with the present invention in position to be connected;

FIG. **3**B is a perspective view of the modular blocks of FIG. **3**A in a partially contacting position;

FIG. **3**C is a perspective view of the modular blocks of FIG. **3**B in a fully contacting position;

FIG. **3**D is a perspective view of the modular blocks of FIG. **3**C in a fully engaged position;

FIG. **3**E is a perspective view of the modular blocks of FIG. **3**D, along with a locking key about to be inserted therein;

FIG. **3**F is a perspective view of the modular blocks of FIG. **3**E, with a locking key partially inserted therein;

FIG. **3**G is a perspective view of the modular blocks of FIG. **3**F, with a locking key fully inserted therein;

FIG. **4**A is a perspective view of a modular block along with a connector plate and connector pin;

FIG. **4**B is a perspective of a plurality of modular blocks connected with connector plates and pins;

FIG. **5**A is a perspective view of a modular block along with a connector plate, connector pin, and a finish element;

FIG. **5**B is a perspective view of a plurality of modular blocks connected with connector plates and pins, and having finish elements attached thereto;

FIG. **6** is a perspective view of a plurality of modular blocks having locking elements oriented in varied directions;

FIG. **7** is a perspective view of a structure built-up from a plurality of modular blocks having locking elements oriented in varied directions;

FIG. **8** is a perspective view of a structure built-up from a plurality of modular blocks having locking elements oriented in the same direction;

FIG. **9** is a perspective view of a truss structure built-up from a plurality of modular blocks;

FIG. **10** is a perspective view of a wall structure built-up from a plurality of modular blocks;

FIG. **11** is a perspective view of a group of modular blocks of different sizes;

FIG. **12** is a perspective view of a modular block adapted to be connected to a plurality of smaller modular blocks;

FIG. **13** is a perspective view of the modular block of FIG. **12** connected to a plurality of smaller modular blocks;

FIG. **14** is a perspective view of another modular block adapted to be connected to a plurality of smaller modular blocks;

FIG. **15** is a perspective view of the modular block of FIG. **14** connected to a plurality of smaller modular blocks;

FIG. **16** is a top perspective view of a modular block constructed according to an alternative embodiment of the present invention;

FIG. **17** is a bottom perspective view of the modular block of FIG. **16**;

FIG. **18** is an enlarged view of a portion of the top of the modular block of FIG. **16**;

FIG. **19** is an enlarged view of a portion of the bottom of the modular block of FIG. **16**;

FIG. **20** is a perspective view of a locking assembly for use with the modular block of FIG. **16**;

FIG. **21** is a top perspective view of a modular block having a locking assembly installed therein;

FIG. **22** is an enlarged view of a portion of the top of the modular block of FIG. **21**;

FIG. **23** is an enlarged view of a portion of the bottom of the modular block of FIG. **21**;

FIG. **24**A is a perspective view of a core forming a portion of a locking assembly;

FIG. **24**B is a perspective view of the core of FIG. **24**A with a locking rod about to be inserted therein;

FIG. **24**C is a perspective view of the core and locking rod of FIG. **24**B connected together;

FIG. **24**D is a perspective view of the core and locking rod of FIG. **24**C with a rod key about to be inserted therein;

FIG. **24**E is a perspective view of the core and locking rod of FIG. **24**C with a rod key fully inserted therein;

FIG. **25** is a perspective view of a lower end of a rod key;

FIG. **26** is a perspective view of a core along with a rod key and a pair of core keys;

FIG. **27** is a perspective view of a plurality of modular blocks connected together;

FIG. **28** is a perspective view of a connector plate;

FIG. **29** is perspective view of a connector plate disposed in a groove of a modular block;

FIG. **30** is a perspective view of the modular block and connector plate of FIG. **29** with a connector pin inserted therein;

FIG. **31** is a perspective view of a pair of modular blocks connected end-to-end with a connector plate and connector pins;

FIG. **32** is a perspective view of another type of connector plate;

FIG. **33** is a perspective view of a plurality of modular blocks of varying sizes connected together;

FIG. **34** is a perspective view of another finish element;

FIG. **35** is a perspective view of a modular block with a plurality of finish elements connected thereto;

FIG. **36** is a perspective view of a rotational connector plate;

FIG. **37** is a perspective view of a modular block with the connector plate of FIG. **36** attached thereto;

FIG. **38** is a perspective view of a plurality of modular blocks connected together;

FIG. **39** is a perspective view of a plurality of modular blocks of varying sizes connected together;

FIG. **40** is a perspective view of the components of a locking assembly of a first size;

FIG. **41** is a perspective view of the components of a locking assembly of a second size;

FIG. **42** is a perspective view of the components of a locking assembly of a third size;

FIG. **43** is a schematic top view of a representative hole pattern in a modular block;

FIG. **44** is a perspective view of a wheeled vehicle constructed from modular blocks;

FIG. **45** is partially exploded view of the vehicle of FIG. **44**;

FIG. **46** is a perspective view of a curved modular block;

FIG. **47** is a perspective view of a cylindrical structure assembled from the modular blocks shown in FIG. **46**;

FIG. **48** is a perspective view of a structure assembled from a combination of curved and straight modular blocks;

FIG. **49** is a perspective view of trapezoidal modular block;

FIG. **50** is a perspective view of a structure assembled from the trapezoidal modular blocks shown in FIG. **49**;

FIG. **51** is perspective view of a lobed modular block;

FIG. **52** is a perspective view of a wall structure assembled from the lobed modular blocks shown in FIG. **51**;

FIG. **53** is a perspective view of the wall structure of FIG. **52** in a pivoted position;

FIG. **54** is a perspective view of a structure assembled from different shapes of modular blocks;

FIG. **55** is a perspective view of a modular block constructed in accordance with another alternative embodiment of the present invention;

FIG. **56** is an exploded perspective view of the block shown in FIG. **55**;

FIG. **57** is a perspective view of a variation of the block shown in FIG. **55**;

FIG. **58** is a perspective view of a key for use with the block of FIG. **55**;

FIG. **59** is another perspective view of the key shown in FIG. **58**;

FIG. **60** is a perspective view of an alternative key for use with the block shown in FIG. **55**;

FIG. **61** is another perspective view of the key shown in FIG. **60**;

FIG. **62** is a partially exploded perspective view of a structure built up from the blocks shown in FIGS. **55** and **57**; and

FIG. **63** is a perspective view of the structure shown in FIG. **62** showing keys being inserted therein.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings wherein identical reference numerals denote the same elements throughout the various views, FIG. **1** illustrates an exemplary modular block **10** constructed according to the present invention. The modular block **10** includes a top surface **12**, a bottom surface **14**, and front, rear, left and right sidewalls **16**, **18**, **20**, and **22**, respectively. An interior cavity **24** is formed in approximately the center of the modular block **10**. The interior cavity **24** includes a generally vertical portion **26** which extends between a locking recess **28** adjacent the bottom surface **14** of the modular block **10**, and a lug receptacle **30** adjacent the top surface **12** of the modular block **10**. A ledge **32** extends laterally partway into to the locking recess **28**. The lug receptacle **30** is a parallel-sided opening having an end boss **34** extending across an end wall thereof at a selected distance from the top surface **12**, and a pair of spaced-apart side bosses **36** and **38** disposed on opposite side walls thereof.

A four-faced locking lug **40** includes an inverted "L"-shaped hook **42** which is sized and shaped to engage the locking recess **28** disposed at its upper end. A lug boss **44** is disposed at each of the lower corners of the locking lug **40**. The lug bosses **44** are disposed in a pattern so that they define a lateral slot **46** around the periphery of the locking lug **40**, which communicates with a vertical slot **48** on each of the faces of the locking lug **40**.

As can be seen in FIG. **1**, the locking lug **40** is assembled to the modular block **10** by first inserting it into the lug receptacle **30** in a downwards direction. The side bosses **36** and **38** pass into opposed ones of the vertical slots **48**. Once the lug bosses **44** have cleared the side bosses **36** and **38** and the end boss **34** in a vertical direction, the locking lug **40** is then shifted laterally so that two of the lug bosses **44** are aligned with the end boss **34**, and two of the lug bosses **44** are aligned with the side bosses **36** and **38**. In this position, the locking lug **40** is prevented from being withdrawn vertically from the lug receptacle **30**.

The dimensions, material, and surface finish of the locking lug **40** may be selected to provide the desired interface with the lug receptacle **30**. For example, if an easily-disassembled joint is desired, a small clearance may be provided between the exterior of the locking lug **40** and the lug receptacle **30**. If a more permanent joint is desired, the locking lug **40** may be provided with a tighter fit in the lug receptacle **30**, for example by providing a slight interference fit, or by providing a relatively rough surface finish.

FIG. **2** illustrates the modular block **10** with the locking lug **40** assembled thereto. In the illustrated example the hook **42** of the locking lug **40** extends towards the left sidewall **20** of the modular block **10**. However, it will be appreciated that the locking lug **40** may be assembled to the modular block **10** so that it points in any one of four directions.

The modular block **10** and the locking lug **40** may be constructed of any material which is suited to the application for which the modular block **10** is to be used and which can be formed into the necessary dimensional features. For example, the modular block **10** may be used as a toy, a modeling element, or a light structural element, in which case it may be molded from a material such as plastic resin. The modular

block **10** may also be used for heavier structural applications, in which case it may be formed from materials such as concrete, wood or engineered wood materials, pressed fiber, metals, or fiber composite materials. Specific applications of the modular blocks **10** are discussed in more detail below.

FIGS. **3**A-**3**G illustrates the two identical modular blocks **10** and **10'** to form a larger structure. Modular block **10** is provided with a locking lug **40** having a hook **42** as described above. As shown in FIGS. **3**B, **3**C and **3**D, the hook **42** is inserted into the locking recess **28'** of the block **10'** and then shifted laterally so that the hook **42** is disposed behind the ledge **32'** of the locking recess **28'**. This prevents the modular blocks **10** and **10'** from being disconnected in a vertical direction.

To secure the blocks together, a key **50** is inserted into the vertical portion **26'** (see FIGS. **3**E and **3**F). The key **50** is an elongated member sized to fit into the vertical portion **26'** of the cavity **24'** (identical to cavity **24**). As shown in FIG. **3**G, the presence of the key **50** prevents lateral motion of the hook **42** relative to the locking recess **28'**. The key **50** may be provided with a cut-back edge **52** that engages a shelf **54** of the lug receptacle (best seen in the identical block **10** of FIG. **2**), to prevent the key **50** from falling out of the bottom of the modular blocks **10** and **10'**. As noted above with respect to the locking lug **40**, the dimensions, materials, and surface finish of the key **50** may be selected to prevent unintended withdrawal.

As shown in FIG. **2**, the modular block **10** includes an array of laterally-extending corner slots **56** formed in each of its vertical edges. A corner hole **58** passes through the modular block **10** near each of its vertical edges and thus intersects the corner slots **56** formed along each vertical edge. FIG. **4**A illustrates components used to connect two or more modular blocks **10** together laterally, including a connector pin **60**, and various connector plates **62**, **64**, **66**, and **68**. The connector pin **60** is an elongated pin sized to fit the corner hole **58**. It may include an enlarged head **70** to prevent it from falling through the modular block **10**. Each connector plate is a flat member having a thickness sized to fit in one of the corner slots **56** of a modular block **10**, and one or more connector pin holes **72**. In the illustrated example, the connector plate **62** has a single hole and is sized to fill in a corner slot **56** but not to perform any joining function. The connector plate **64** is rectangular and has two connector pin holes **72** therein. The connector plate **66** is "L"-shaped and has three connector pin holes **72**. Finally, the connector plate **68** is square and has four connector pin holes **72** therein.

FIG. **4**B illustrates several modular blocks **10**, **10'** and **10"** connected together. The modular blocks **10**, **10'** and **10"** meet at a common vertical edge **74**, and connector plates **68** are inserted into corner slots **56** of each of the modular blocks **10**, **10'**, and **10"**. A connector pin **60** is then inserted into the corner holes **58** of each of the modular blocks **10**, **10'**, and **10"**. This secures each of the modular blocks **10**, **10'**, and **10"** to the connector plates **68** and thus secures the modular blocks **10**, **10'**, and **10"** to each other, in both lateral and vertical directions.

FIG. **5**A illustrates a modular block **10** along with a connector pin **60**, connector plates **62**-**68**, and a finish element **76**. The finish element **76** has a planar inner side **78** which is sized and shaped to mate with a side wall of the modular block **10**. The inner side **78** includes one or more connector tabs **80** with connector pin holes **72** therein. The connector tabs **80** are positioned and sized to fit into corner slots **56** of the modular block **10**. The finish element **76** has an exterior surface **82** with one or more sides or facets which are formed into a desired shape. In the illustrated example, the exterior surface of the finish element **76** is shaped to form a portion of a cylinder.

FIG. **5**B illustrates several modular blocks **10**, **10'**, **10"**, and **10'"** connected together with several finish elements **76**, using the connector plates **68**, connector tabs **80**, and connector pins **60** as described above to form a solid structure with a cylindrical outer surface. As can be observed from FIG. **5**B, the use of finish elements **76** allows the creation of structures that are essentially modular, but which have arbitrary external shapes.

FIG. **6** illustrates a plurality of building elements **84**. Each of these building elements **84** has multiple "L"-shaped hooks **42** extending from an upper surface thereof, and multiple locking recesses **26** on a lower surface thereof. The building elements **84** can be made as a single element, or built up from individual modular blocks **10**. The direction that each hook **42** faces can be arbitrarily selected to suit a particular application. In FIG. **6**, each hook labeled **42**A is facing towards the left of the page, each hook labeled **42**B is facing towards the bottom of the page, each hook labeled **42**C is facing towards the right of the page, and each hook labeled **42**D is facing towards the top of the page. If the eight hooks **42** on each building element **84** are divided into groups of four, there are then 16 possible combinations of hook directions. FIG. **7** illustrates a structure which is built up from building elements **84** having hooks **42** facing in different directions, while FIG. **8** illustrates a structure which is built up from building elements having hooks **42** all facing in a single direction.

FIG. **9** illustrates an example of a truss structure **86** which may built up from the modular blocks **10** described above. The modular blocks **10** are connected side-by side and vertically to form longitudinal members **88**, lateral members **90**, and vertical members **92**. Tapered blocks **94** are disposed at the upper ends of the vertical members **92** so that the uppermost longitudinal members **88** will be at the proper angle.

FIG. **10** illustrates a ladder truss-type structure **96** having longitudinal members **98** and lateral members **100** which may be built up from modular blocks **10** described above.

FIG. **11** illustrates a modular block **10** alongside additional modular blocks **110** and **112**. The modular blocks **110** and **112** are substantially identical in construction to the modular block **10**, and include hooks **114** and **116**, and locking recesses **118** and **120**, respectively. The modular blocks **110** and **112** differ from the modular block **10** in their size. This may vary from a size small enough to construct items such as electronic circuit boards, to as many as several feet on a side for elements for constructing buildings.

FIG. **12** illustrates a modular block **122** which is designed to serve as an "adapter" for connection to different-sized modular blocks. The modular block **122** includes a single locking recess **124** on its lower side. Four "L"-shaped hooks **126** protrude from the upper surface of the modular block **122**. As shown in FIG. **13**, this allows the modular block **122** to be connected to additional modular blocks **128** and **130** which are each one-quarter of the size of the modular block **122**.

FIG. **14** illustrates another modular block **132** which is designed to serve as an "adapter" for connection to different-sized modular blocks. The modular block **132** includes a single "L"-shaped hook **134** protruding from its upper surface. Four locking recesses **136** are disposed on its lower side. As shown in FIG. **15**, this allows the modular block **132** to be connected to additional modular blocks **138** which are each one-quarter of the size of the modular block **132**.

FIGS. **16** and **17** illustrate an exemplary modular block **200** constructed according to the present invention. The modular block **200** is generally rectangular and includes a top surface

212, a bottom surface 214, and front, rear, left and right sidewalls 216, 218, 220, and 222, respectively. A plurality of generally cylindrical core passages 224 of various sizes pass through the modular block 200 from top to bottom. As shown in more detail in FIG. 18, each core passage 224 has an enlarged-diameter counterbore 226 formed at its upper end. As shown in more detail in FIG. 19, each core passage 224 has a plurality of semi-cylindrical key slots 228 formed around the periphery of its lower end.

FIG. 20 illustrates an exemplary locking assembly 230, which includes a core 232, a locking rod 234, one or more core keys 236, and a rod key 238, all of which are described in more detail below. The locking assembly 230 is received in one of the core passages 224 of a modular block 200 to enable the modular block 200 to be connected to other blocks, as shown in FIG. 21. The locking assembly 230 fits in the core passage 224 so that the upper end of the core 232 fits flush with the top surface 212 of the modular block 200, as shown in FIG. 22, and the lower end of the core is flush with the bottom surface 214 of the modular block 200, as shown in FIG. 23.

FIGS. 24A through 24E illustrate the assembly sequence of the locking assembly 230. Referring to FIG. 24A, the generally cylindrical core 232 has an enlarged boss 240 formed at its upper end which is sized and shaped to fit into the counterbore 226 of the core passage 224. The core 232 has a through-bore 242 passing along its length. Approximately one-half of the through-bore 242 defines a series of alternating semi-cylindrical core grooves 244 and core lands 246. The core grooves 244 have a first inner diameter, and the core lands 246 have a second inner diameter which is smaller than the first inner diameter. The remaining portion of the through-bore 242 is formed into a semi-cylindrical passage 247 having an inner diameter somewhat larger than the first inner diameter.

FIG. 24B illustrates a locking rod 234. The locking rod 234 is generally cylindrical. Its outer surface defines a series of alternating cylindrical rod grooves 248 and rod lands 250. The rod lands 250 have a first outer diameter which is approximately equal to the first inner diameter of the core grooves 244, and the rod grooves 248 have a second outer diameter which is approximately equal to the second inner diameter of the core lands 246.

FIG. 24C shows the locking rod 234 inserted into the core 232 and shifted laterally so that the rod lands 250 engage the core grooves 244, and the rod grooves 250 engage the core lands 246. Thus engaged, the locking rod 234 is prevented from moving axially relative to the core 232. The locking rod 234 is inserted approximately halfway into the core 232, so that a space will be left in the core for receiving another locking rod 234 in a manner described below.

FIG. 24D shows a rod key 238 about to be inserted into the core 232. The rod key is an elongated, arcuate cross-section member with a laterally-extending lip 252 at its upper end. The outer wall 254 of the rod key 238 mates with the semi-cylindrical passage 247 of the core 232, and the inner wall 256 of the rod key 238 mates with the rod lands 250. When the rod key 238 is fully inserted into the core 232, it prevents the locking rod 234 from shifting laterally and thus retains it in the core.

A pair of oblong core keys 236, best seen in FIG. 26, are disposed in core key openings 258 near the bottom end of the core 232 so that they can slide transversely to the long axis of the core 232. The rod key 238 has opposed chamfers 260 at its bottom end (see FIG. 25) which engage the core keys 236 and force them outwards as the rod key 238 is fully inserted into the core 232.

The locking assembly 230 is attached to a modular block 200 as follows. First, the core 232 with retracted core keys 236 is inserted into one of the core passages 224 of the modular block 200. The locking rod 234 is then inserted into the through-bore 242 and shifted laterally as described above. The rod key 238 is then inserted into the core 232, securing the locking rod 234 in place and also forcing the core keys 236 outward. As seen in FIG. 23, the core keys 236 engage the key slots 228 of the core passage 224. The entire locking assembly 230 is thus securely attached to the modular block 200 and cannot be removed until the rod key 238 is removed. If desired, the materials, dimensions, and finish of the rod key 238 may be chosen to prevent its unintended removal from the core passage 224. Furthermore, the rod key 238 may be provided with a means for assisting its removal, such as a fingernail slot or tool ledge (not shown).

FIG. 27 shows a group of modular blocks 200, 200', and 200" connected together with a plurality of locking assemblies 230. To assemble the modular blocks 200 and 200' together, a locking assembly 230 is first installed into a core passage 224 so that approximately half of the locking rod 234 extends upward from the top surface 212 of the modular block 200 (see FIG. 21). Then, a second core 232' is inserted into the upper modular block 200' without a locking rod 234 or rod key 238. The locking rod (obscured in FIG. 27) is inserted into the second core 232' and shifted laterally so that its grooves and lands engage the grooves and lands of the second core 232', similar to the manner described above with respect to FIGS. 24A-24E. At this point, the modular blocks 200 and 200' are assembled in an upper-and-lower touching relationship. If desired, a second locking rod 234' may be inserted into the second core 232 and engaged with the grooves and lands thereof. A second rod key 238' is then inserted into the second core 232 to lock both of the locking rods 234 and 234' into place in the second core 232' and prevent disassembly of the modular blocks 200 and 200'.

FIG. 28 illustrates a connector plate 262 for being used to join two or more modular blocks 200 together side-by-side. The illustrated connector plate 262 is a flat member having a thickness sized to fit in a connector slot 264 formed in the periphery of a modular block 200 (see FIG. 29). One or more connector pin holes 266 are formed through the connector plate 262. In the illustrated example, the connector plate 262 is rectangular and has a two-dimensional array of connector pin holes 266 therein.

As shown in FIGS. 29 and 30, some of the core passages 224 in the modular block 200 intersect the connector slots 264 thereof. A connector pin 268, is sized to fit the core passage 224. It may include an enlarged head 270 to prevent it from falling through the modular block 200.

FIG. 31 illustrates two modular blocks 200 and 200' connected end-to-end. A connector plate 262 is inserted into connector slots 264 of each of the modular blocks 200 and 200'. A connector pin 268 is then inserted into core passages 224 of each of the modular blocks 200 and 200', passing through the connector pin holes (obscured in FIG. 31). This secures each of the modular blocks 200 and 200' to the connector plate 262 and thus secures the modular blocks 200 and 200' to each other, in both lateral and vertical directions.

FIG. 32 illustrates another connector plate 272 for being used to join two or more modular blocks 200 together. The illustrated connector plate 272 is substantially similar to the connector plate 262 described above, differing only in the fact that it includes an array of relatively small-diameter connector pin holes 274A, and another array of relatively larger connector pin holes 274B are formed through the connector plate 272. The connector plate 272 can be used to join modu-

lar blocks **200** having different-sized core passages **224**. As shown in FIG. **33**, this allows the joining of relatively large modular blocks **200** and **200'** with a smaller modular block **200"**.

FIG. **34** illustrates a finish element **276**. The finish element **276** has a planar inner side **278** which is dimensioned and shaped to mate with a side wall of the modular block **200**. The inner side **278** includes one or more connector tabs **280** with connector pin holes **282** therein. The connector tabs **280** are positioned and sized to fit into the connector slots **264** of the modular block **200**. The finish element **276** has an exterior surface **284** with one or more sides or facets which are formed into a desired shape. In the illustrated example, the exterior surface **284** of the finish element **276** is shaped to form a portion of a cylinder.

FIG. **35** illustrates a modular block **200** with several finish elements **276** attached thereto. They may be secured with connector pins (not shown) as described above, to form a solid structure with a cylindrical outer surface. The use of finish elements **276** allows the creation of structures that are modular, but which have arbitrary external shapes.

FIG. **36** illustrates another type of connector plate **286**. The connector plate **286** is a flat member having a thickness sized to fit in a connector slot **264** formed in the periphery of a modular block **200**. An array of connector pin holes **288** are formed through the connector plate **286**. One or more cylindrical studs **290**, each having at least one cylindrical land **292** and one cylindrical groove **294**, are attached to the connector plate **286** and are extend parallel to the plane thereof. The installation of the connector plate **286** into a connector slot **264**, as shown in FIG. **37**, gives the side of a modular block **200** the same connectivity as the top of the modular block **200**. More particularly, the studs **290** perform the same function as the locking rods **236** so that a modular block **200'** can be connected to the side of a modular block **200** (see FIG. **38**).

FIG. **39** illustrates how various sizes of modular blocks **200**, **200'**, **200"**, **200'"**, and **200""** may be connected to each other by using appropriately-sized locking assemblies **230** in the core passages **224**. Exemplary locking assemblies **230**, **296**, and **298**, varying only in the size of their constituent components, are shown in FIGS. **40**, **41**, and **42**, respectively. The use of these different-sized locking assemblies **230**, **296**, and **298** is enabled by the provision of different-sized core passages **224** in the modular blocks **200**. As shown in FIG. **43**, these core passages **224** are laid out in a regular grid pattern within the modular block **200**.

FIGS. **44** and **45** illustrate an example of how a complex structure, in this case a wheeled vehicle, can be built up from the components described above, including modular blocks **200**, locking assemblies **230**, finish elements **276**, connector plates **286**, and connector pins **268**

The modular blocks need not be square or rectangular. For example, FIG. **46** illustrates a curved modular block **300**. The curved modular block **300** includes a top surface **312**, a bottom surface **314**, and front, rear, left and right sidewalls **316**, **318**, **320**, and **322**, respectively. The front and rear sidewalls **316** and **318** are curved into parallel arcs. A plurality of generally cylindrical core passages **224** pass through the curved modular block **300** from top to bottom. As shown in FIGS. **47** and **48**, these curved modular blocks **300** can be used solely with other curved modular blocks **300**, or with rectangular modular blocks **200** to form structures with a desired shape.

FIG. **49** illustrates a trapezoidal modular block **400**. The trapezoidal modular block **400** includes a top surface **412**, a bottom surface **414**, and front, rear, left and right sidewalls **416**, **418**, **420**, and **422**, respectively. The left and right sidewalls **420** and **422** are angled in opposite directions. A plurality of generally cylindrical core passages **224** pass through the curved modular block **300** from top to bottom. As shown in FIG. **50**, these trapezoidal modular blocks **400** can be used with other trapezoidal modular blocks **400** to produce polygonal structures.

FIG. **51** illustrates a lobed modular block **500** which includes a top surface **512**, a bottom surface **514**, and a continuous sidewall **516**. The sidewall **516** is curved into a shaped having a pinched-in "waist" **518** disposed between two cylindrical lobes **520**. A generally cylindrical core passage **224** passes through the lobed modular block **500** from top to bottom at the center of each lobe **520**. As shown in FIGS. **52** and **53**, these lobed modular blocks **500** can be used to build up wall-like structures which can pivot about the locking rods **500** which hold them together.

Any of the various shapes of modular blocks described above may be attached to any other shape as long as a core passage is available. An example of a structure built up from various block shapes is shown in FIG. **54**.

FIG. **55** illustrates another alternative modular block **600** constructed according to the present invention. The modular block **600** includes a top surface **610**, a bottom surface **612**, and front, rear, left and right sidewalls **614**, **616**, **618**, and **620**, respectively. An interior space **621** is defined along the central portion of the modular block **600**. As shown more clearly in FIG. **56**, the modular block **600** is built up from two side members **622**A and **622**B, and one or more locking lugs **624**. Each of the side members **622** has an inner surface **626** and an outer surface **628**. The inner surface **626** of each side member **622** is generally planar and has a plurality of key grooves **623** formed therein. Because the inner surfaces **626** are identical, the side members **622** may be produced in large quantities by providing a workpiece with a flat surface, machining long, continuous grooves in the flat surface, and then cutting the workpiece into individual side members **622**.

Each of the locking lugs **624** includes upper and lower notches **630**A and **630**B formed near its upper and lower ends. These notches **630** are positioned and sized so as to define "L" shaped upper and lower hooks **632**A and **632**B, respectively. The hooks **632** are sized to engage the notches **630**.

Referring again to FIG. **55**, the locking lugs **624** are assembled to the modular block **600** by clamping them between the side members **622**A and **622**B. It will be appreciated that the locking lug **624** may be assembled to the modular block **600** so that it points in any one of four directions. In FIG. **55** the upper hooks **632**A of the locking lugs **624** extend towards the front endwall **614** of the modular block **600**, whereas in FIG. **57**, the upper hooks **632**A' of the locking lugs **624'** extend towards the right sidewall **620'** of the modular block **600'**. The components may be secured together by adhesives, welding, thermal or sonic bonding, fasteners, or any other method that will create a unitary whole. The entire modular block **600** may also be formed as an integral component, for example by casting it from a mold.

The modular block **600** and the locking lug **624** may be constructed of any material which is suited to the application for which the modular block **600** is to be used and which can be formed into the necessary dimensional features. For example, the modular block **600** may be used as a toy, a modeling element, or a light structural element, in which case it may be molded from a material such as plastic resin. The modular block **600** may also be used for heavier structural applications, in which case it may be formed from materials such as concrete, wood or engineered wood materials, pressed fiber, metals, or fiber composite materials. In the illustrated example, the modular block **600** includes an exte-

rior fascia **601** intended to present a finished appearance. The fascia **601** may be formed as an integral part of the modular block **600**, or it may be added to the exterior of the modular block **600**, for example by building up a layer of mortar, joint compound, or the like, and applying an appropriate finish thereto.

FIGS. **58** and **59** illustrate a key **634** to be used with the modular blocks **600**. The key **634** is an elongated member sized to fit into the interior space **621**. The key **634** has an upper end **636** with an alignment pin **638** protruding therefrom, and a lower end **640** with a complementary alignment hole **642** formed therein. The key **634** also includes at least one alignment rail **644** adapted to engage the key grooves **623**. In the illustrated example, the body of the key **634** is an "H" shaped cross-section, and the alignment rail **644** is formed by positioning a dowel between the uprights of the "H" section. This simplifies manufacture of the key **634**.

FIGS. **60** and **61** illustrate an alternative key **646**. The key **646** is substantially similar to the key **634** and has an upper end **648** with an alignment pin **650** protruding therefrom, and a lower end **652** with a complementary alignment hole **654** formed therein. The key **646** also includes at least one alignment rail **656** adapted to engage the key grooves **623**. In the illustrated example, the body of the key **656** is generally rectangular, and the alignment rails **656** are formed by positioning dowels within slots **658** in the surface of the key **656**.

FIGS. **62** and **63** illustrate how a plurality of modular blocks **600** may be assembled to form a larger structure. A first modular block identified as **600**A is positioned down over the locking lugs **624** of one or more other modular blocks **600**B, **600**C, and then shifted laterally so that the hooks **632** of the modular blocks **600**B and **600**C engage the notches (not visible in FIG. **62**) in the locking lugs **624** of the first modular block **600**A. This prevents the modular blocks **600**A, **600**B, and **600**C from being disconnected in a vertical direction. In creating the assembled structure, the orientation of the locking lugs **624** are preferable chosen so that the hooks **632** will all be facing in the same direction regardless of the orientation of the modular blocks **600**. For example, in FIG. **62**, the modular block identified as **600**D has its hooks **632** facing perpendicular to its long axis.

To secure the modular blocks **600** together, one or more keys are inserted into the central spaces **621**, with the alignment rails **644** engaging the key grooves **623** of both an upper modular block **600**A, and the modular block **600**C below it (see FIG. **63**). The engagement of the key **634** prevents lateral motion of the hook **632** relative to the notches **630**. A larger key **646** has multiple alignment rails **656** and therefore holds together two adjacent modular blocks **600**A and **600**E by engaging key grooves **623** in each of the blocks **600**A and **600**D. The dimensions, materials, and surface finish of the keys **634** and **646** may be selected to prevent unintended withdrawal.

The modular blocks (for example items **10**, **200**, **300**, **400**, **500**, and **600**) described above may be used for any type of construction which requires or would benefit from a modular characteristic. Several non-limiting examples of possible applications for theses blocks will now be set forth, without regard to a particular embodiment of the blocks themselves. Of course, the modular blocks can be used as toys or as small-scale modeling elements when produced in a proper size, say a few centimeters on a side.

When produced in larger sizes, they may be used for residential or commercial building elements such as walls, roofs, floor, retaining walls, and windows (if made from transparent or translucent material). They may also be used to construct industrial structures such as factory floors, machine tool bases and machine bodies.

The modular blocks can also be used to build marine structures such as piers, barges, underwater structures, and boat hulls.

On a smaller scale, the modular blocks may be used to build up three-dimensional circuit cards, or if made of bio-compatible materials, they may be used to form three-dimensional frames for bone or organ tissue construction. If reduced to a sufficiently small scale, they can be used for nanostructures.

The modular blocks may be formed out of armor material or projectile-resistant material, such as KEVLAR aramid fibers. These armored blocks can be used to form containers to ship military supplies. After the supplies are received at the destination, the containers can then be disassembled into modular blocks. These blocks can then be used to construct custom made protective shields for personnel or equipment. Shipping containers may also be made from more conventional construction materials and then used to ship food, water, or other supplies to disaster areas. After the supplies are received, the shipping containers may be disassembled into modular blocks and then used for low-cost buildings that can be quickly erected.

The foregoing has described a modular block and a method of construction using such modular blocks. While specific embodiments of the present invention have been described, it will be apparent to those skilled in the art that various modifications thereto can be made without departing from the spirit and scope of the invention. Accordingly, the foregoing description of the preferred embodiment of the invention and the best mode for practicing the invention are provided for the purpose of illustration only and not for the purpose of limitation.

What is claimed is:

1. A modular block system, comprising:

a first block cooperatively formed by first and second side members arranged with their interior surfaces facing each other and spaced-apart to define interior space therebetween, and at least one locking lug positioned between and interconnecting the side members, the locking lug comprising a first hook at one end thereof vertically adjacent a notch and protruding beyond a top surface of the block, and a second hook at an opposing end thereof vertically adjacent a notch and positioned within the interior space, wherein the first and second hooks face in opposing directions generally perpendicular to the side members; and

a second block cooperatively formed by first and second side members arranged with their interior surfaces facing each other and spaced-apart to define interior space therebetween, and at least one locking lug positioned between and interconnecting the side members, the locking lug comprising a first hook at one end thereof vertically adjacent a notch and protruding beyond a top surface of the block, and a second hook at an opposing end thereof vertically adjacent a notch and positioned within the interior space, wherein the first and second hooks face in opposing directions generally parallel to the side members;

wherein the first hook of the lug of the second block engages within the notch vertically adjacent the second hook of the lug of the first block when the first and second blocks are arranged vertically adjacent to each other; and

wherein the interior surface of each of the first and second side members of the first and second blocks have at least

one key groove extending continuously from the top of each block to the bottom of each block for receiving a key.

2. The modular block system of claim **1** wherein the side members and the locking lug are a single integral component.

3. The modular block system of claim **1** further comprising a key received in the interior space of the blocks having an alignment rail that engages within the at least one key groove of the blocks, the key extending between vertically adjacent arranged blocks to prevent relative lateral movement therebetween.

4. The modular block system of claim **3** wherein the key includes at least two spaced-apart alignment rails that are adapted to engage respectively within opposing key grooves of the first and second side members of the first and second blocks.

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